CONTERIBUTION OF AGRICULTURAL GROWTH PROGRAM IMPLEMENTED ARICULTURAL PRACTICES TO CLIMATE SMART AGRICULTURE AND THEIR DETERMINANTS IN EFRATANA GIDM DISTRICT OF NORTH SHEWA, ETHIOPIA

M.Sc. THESIS

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DEGREE OF

MASTER OF SCIENCE IN CLIMATE SMART AGRICULTURAL LAND SCAPE ASSESSMENT

JUNE, 2020

APPROVAL SHEET-I

APPROVAL SHEET-I

This is to certify that the thesis entitled as ***"Contribution of Agricultural Growth Program implemented agricultural practices to Climate Smart Agriculture and their determinants in Efratana Gidm district of North Shewa, Ethiopia***" submitted in partial fulfillment of the Degree of Master of Science in **Climate Smart Agricultural Landscape Assessment**, Wondo-Genet College of Forestry and Natural Resource, and is a record of original research carried out by ***Dereje Mandefro*** under my supervision, and no part of the thesis has been submitted for any other degree or diploma.

The assistance and help receive during the courses of this investigation have been duly acknowledged. Therefore, I recommend that it is to be accepted as fulfilling the thesis requirement.

Beyene Teklu /PhD/		24/06/2020
Name major advisor:	Signature	Date

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APPROVAL SHEET-II

We, the undersigned, members of the Board of examiners of the final open defense by Dereje Mandefro have read and evaluated his thesis entitled "***Contribution of Agricultural Growth Program implemented agricultural practices to Climate Smart Agriculture and their determinants in Efratana gidm District of North Shewa, Ethiopia***" and examined the candidate. This is therefore to certify that the thesis has been accepted in partial fulfillment of the requirements for the degree of Master of Science in Climate Smart Agricultural Landscape Assessment**.**

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ABBREVIATIONS /ACRONYMS

AGP	Agricultural Growth Program
CSA	Central Statistical Agency
CSA	Climate Smart Agriculture
CV	Coefficient of Variation
Das	Development Agents
EGDOA	EfratanaGidm District Office of Agriculture
EHNRI	Ethiopian Health and Nutrition Research Institute
FAO	Food and Agricultural Organization
FDRE	Federal Democratic Republic of Ethiopia
FGD	Focused Group Discussion
FSSR	Food Self-Sufficiency Ratio
FTC	Farmer Training Center
GDP	Gross Domestic Product
GHG	Green House Gas
GTP	Growth and Transformation Plan
Ha	Hectare
HH	Household
IPCC	Inter-governmental Panel on Climate Change
KIs	Key Informants
MoA	Ministry of Agriculture
Qt	Quintal
SD	Standard Deviation
SPSS	Statistical Package for Social Science
TLU	Total Livestock Unit
UNDP	United Nations Development Program
UNICEF	United Nations Children's Fund

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ABSTRACT

In countries like Ethiopia where climate change imposed recurrent droughts cause crop failure and death of livestock, identifying and adopting climate smart agricultural practices can be considered as a panacea. In line with this the agricultural growth program has been implementing varies climate smart agricultural technologies in different parts of Ethiopia and yet there is little information on their contribution to income and food self-sufficiency and factors affecting their adoption. This study was initiated with main objective to assess the contribution of agricultural growth program implemented agricultural practices to climate smart agriculture and their determinants in Efratana gidm District of North Shewa, Ethiopia by employing cross-sectional data collection tools. A multi-stage purposive and stratified random sampling technique was used and survey was conducted with a total of 204 respondents categorized into adopters (139) and non-adopters (65). The result indicated that adopters had significantly larger farm size (1.19 ha) and herd size (3.19 TLU) compared to 0.78 ha and 1.8 TLU respectively for non-adopters. Adopters also had better access to credit and extension services than non-adopters. A total of 11 climate smart practices were adopted and of the total 6 were nutrient smart and 3 carbon smart technologies. Adoptions of these technologies helped adopters to produce significantly larger crop yield and obtain significantly higher income (ETB 51,347.3) than non-adopters (ETB 32,160.1). The food self-sufficiency ratio for adopters were 2.18 while 1.75 for non-adopters. Adoption of climate smart agricultural practices were significantly positively influenced by level of education, credit and extension services, labour availability, farm and herd size while significantly negatively influenced by distance of the farm field from homestead. Further research should be undertaken on farmers' knowledge and their existing experience about prioritization of agricultural practices.

Key words: *Adoption, climate smart, factors, food self-sufficiency, income*

1. INTRODUCTION

1.1. Background

Climate change and variability are an incremental modern-day threat to agricultural production, food security and livelihoods for millions of people all over the world (IPCC, 2014). Agriculture is the main stay of about 85% of Ethiopian population besides its contribution of about 90% for foreign exchange earnings (Abebaw *et al.,* 2010). According to the Federal Democratic Republic of Ethiopia (FDRE) Growth and Transformation Plan (GTP) II (2016), agriculture sector contributed 39% of GDP. Although agriculture has been considered as the backbone of Ethiopian economy, its reliance entirely on rain fall make it vulnerable to changes in weather conditions (Andersson *et al*., 2009). The negative implication of climate change on agricultural sector is explained by crop failure, lack of feed-imposed livestock deaths, which lead to famine and poverty. The drought stroke Ethiopia in 2015 which make more than 27 million people to food expose 18.1 million people to food assistance (Abduselam, 2017) was one of the climate change manifestation. This implies the significantly higher vulnerability of rain fed agriculture to climatic change. In countries like Ethiopia where about 23.4% of the population lives below the poverty line of $ 1.9 per day and 10% of the citizens are chronically food insecure (GTP-II (2016 and UNICEF 2014) the effect of climate change is worse.

In response to the prevailing climate change an impact, Ethiopia government has been implementing varies strategies which have a role to curb the effect of climate variability on agriculture. Climate-Smart Agriculture (CSA) is among the strategy being promoted widely to transform agriculture under a changing climate (FAO, 2013; Nkonya *et al*., 2018). CSA is an approach that aims to transform agricultural systems and support food security under changing climate through providing context-specific, socially acceptable and flexible solutions (Lipper *et al*., 2014). Climate Smart Agriculture addresses the challenges which climate change (CC) poses to agricultural production. It is a pathway towards sustainable development and food security and is built on three pillars: (i) Increasing agricultural productivity (crops and livestock) and income (ii) Enhancing resilience or adaptation of livelihoods and ecosystems towards climate extremes (iii) Reducing and removing GHG emissions from the atmosphere (FAO 2016). CSA integrates climate change into the planning and implementation of sustainable agriculture and informs priority setting.

In line with this, agricultural growth program (AGP) under growth and transformation program (GTP_II) has been implemented over the eight years in Ethiopia with the aim to transform agriculture (GTP-II 2016). Within the AGP a wide number of agricultural production technologies and practices fall under CSA such as stress-adapted crop and livestock breeds, improved water management technologies (e.g. small-scale irrigation), agroforestry and conservation agriculture, crop diversification, integrated soil fertility management practices (e.g. mulching and rotations) and others have been implemented (FAO 2013; GTP-II 2016). In one way or the other, all implemented agricultural practices contributes to the achievement the three pillars of climate smart agriculture. However, there is little information on the contribution of AGP implanted agricultural practices to climate smart agriculture and factors affecting their implementation. Understanding the contribution of AGP implemented agricultural practices to climate smart agriculture (CSA) helps to design integrated CSA approach to in the way to maximize their benefits (World Bank 2015, FAO 2015).

The study area of Efratana gidm is not exceptional as AGP has implemented various CSA practices with the aim to realize row planting, crop rotation, intercropping, utilization of improved seed, improved soil fertility and composting are among CSA practices implemented since 2015 (GTP-II, 2016). Therefore, this study was initiated to assess contribution of agricultural growth program implemented agricultural practices to climate smart agriculture and their determinants in the study area of Efratana gidm District, North Shewa Zone, Amhara National Regional State, Ethiopia.

1.2. Statement of the problem

Climate smart agricultural production as an approach helps to transform and re-orient the farming system at household and landscape level to support food security under the new realities of climate change (FAO, 2013). In spite of the development of climate smart agriculture technologies, practices and the gains arising from its wide-scale adoption of CSA practices. However, remains a challenge especially amongst smallholder farmers in Africa in general and in Ethiopia in particular (Barnard, 2015). Consensus and recognition is reached by different governmental and non-governmental stakeholders on importance of the CSA approach but there is a gap in implementation and scaling up/out to the local context (Barnard, 2015).

There is a lack of context specific and adequate research findings on CSA practices in Ethiopia for the various agro-ecology, soil type, rainfall pattern, farming system, temperature and moisture ranges (Jirata et al., 2016). A study conducted at national level in Ethiopia has identified that the adoption rate of CSA practices is low and there is a gap in research at local level regarding CSA scoping study. Key challenges such as weak capacity (especially the lack of skilled human resources), weak coordination, frequent land ploughing and removal and burning of crop residues, open grazing, land degradation and the loss of forests are identified at national level and recommendation was made to conduct the study at local context.

The concept of the new approaches of Climate Smart Agriculture (CSA) is not well introduced among the local community and different stakeholders in the study area but few programs are being attempted to be implemented by government and non-government organizations. Extension program in the Growth and Transformation Plan (GTP I and II), Agricultural Growth Program (AGP II) is one of the Climate Smart Agriculture integrated program implemented since the year 2010/11 in the Efratana gidm district. According to the Efratana gidm district GTP-II (2016) the AGP-II program has a Climate Smart crop production component with intervention in the area of soil and water conservation, irrigation, crop rotation, intercropping, soil and water conservation, composting and manure management, integrated crop and livestock diversification, improved and short season crops, crop covers/mulching and control of integrated weed, pest and diseases management. During the preliminary research idea assessment discussions were made with government and partner organization‘s focal persons and no evidence was gained regarding any research done on the topic at the area under study.

In the Efratana gidm district, where the present study was carried out, climate change impact on agricultural production is higher but, information about climate smart agriculture practice on agricultural growth program and its contribution on household level food self-sufficiency and incomes were generally lacking.

1.3. Research objective

1.3.1. General objective

The overall objective of this study was to assess the contribution of agricultural growth program implemented agricultural practices to climate smart and their determinants in the study area.

1.3.2. Specific objectives

- To assess the type of agricultural practices implemented by agricultural growth program (AGP) in the study area.
- To assess the contribution of implemented agricultural practices for CSA by considering productivity and income as indicators for pillar one.
- To evaluate the contribution of implemented agricultural practices for food self sufficiency of income of smallholder farmers in the study area.
- To assess factors that influences the adaptation of agricultural practices implemented by AGP in the study area.

1.4. Research questions

- What are the types of agricultural practices implemented by AGP in the study area?
- How agricultural growth program contribute to effective climate smart agriculture and food self-sufficiency to farmers?
- What climate smart agricultural practices are currently being used by small holder farmers in the study area?
- What are the factors to influence the adaptation of agricultural practices implemented by agricultural growth program in the study area?

1.5. Significance of study

Contribution of agricultural growth program implemented agricultural practices for climate-smart agriculture was highly provide to sustainable increasing productivity and enhances food self sufficiency. This study was considered to be an important step in producing information on contribution of agricultural growth program implemented agricultural practices for climate smart agriculture in Efratana gidm district. The study recognized the information gap about the contribution of agricultural growth program for climate-smart agriculture practice in the study area. Specifically, the result of the study is expected to have the following contributions:

- Factors that influence the choice of CSA practices in the smallholder production systems.
- Effectiveness of the CSA practices by agricultural growth program in the study area.
- Provide recommendations about possible strategies for climate-smart agriculture practice to insure incomes of household in the study area.

Therefore, the output of this study may be utilized by the researcher as well as the planner, decision makers and local people concerned with developing a strategy on climate change prone areas to promote and improve the contribution of agricultural growth program implemented agricultural practices for climate smart agriculture, and give insight about climate change adaptation and mitigation measures in the study area.

1.6. Scope and Limitation of the Study

Conceptual scope-This study was assessed the contribution of agricultural growth program implemented agricultural practices for climate smart agriculture to households income based on the inter link of access to production, income and climate change adaptation.

Methodological scope-204 sample household heads were selected by simple random sampling method the study area to analyze and to give conclusion and recommendations. The study was limited on household heads those who have using climate smart agricultural practices.

Geographical scope-The study was conducted in EfratanaGidm district in the selected sample areas of three kebeles.

Limitation of the study- This study was limited to assess the contribution of agricultural growth program implemented agricultural practices for climate-smart agriculture among smallholder farmers. However, as compared to the study population of 3363 agricultural growth program beneficiary households in selected area, the sample household limited to 204 may affect the degree of representation. There were above 15 kebeles which practices agricultural growth program in the district; however, due to limited resources (budget, time, and facilities) the study was limited to only three kebeles.

2. LITERATURE REVIEW

2.1. Definition and explanation of relevant concepts

Climate Smart Agricultural practices: FAO defined CSA as agricultural activity that is: sustainably and efficiently increases productivity and incomes (adaptation), reduces or removes greenhouse gases emissions (mitigation), enhances achievement of national food security and development goals (FAO, 2010).

Climate smart agriculture is an approach for transforming and reorienting agricultural development under the realities of climate change (Lipper *et al*., 2014). Its goal is to achieve sustainable agricultural development for food security via three "pillars" sustainably, adapting to climate change and reducing and/or removing GHG.

Climate change: A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcing, and/or to persistent anthropogenic changes in the composition of the atmosphere or in land use (IPCC, 2012).

Agricultural Growth Program: Agricultural Growth Program project (AGP) is to increase agricultural productivity and market access for key crop and livestock products in targeted Woreda with focused attention to women and youth (World Bank 2010: 2). Increased smallholder productivity and value-added in the agricultural sector are core elements of the Ethiopian Government's approach to poverty reduction.

Adaptation: Adaptation refers to activities that make people, ecosystems and infrastructure less vulnerable to the impacts of climate change (Shanahan *et al*., 2013).

Adoption: a decision to make full use of on innovation as the best course of action available (Rogers, 2003).

Small holder farmers: is a farmer with limited land availability and resource poor farmers. Those farmers are characterized with limited capital (including animals), fragmented land holdings and limited access to inputs. They are risk prone and vulnerable in different conditions. They mostly have relatively small farm sizes and are unable to satisfy their commitment (FAO, 2015). It maintains that agriculture is predominantly on a smallholder basis in Ethiopia. About 90% of farm holdings are less than two hectares in size.

2.2. Overview of Climate Change and Agriculture

Climate change is a change of climate which is attributed directly or indirectly to human activity. It alters the composition of the global and/or regional atmosphere and natural climate variability observed over comparable time periods (IPCC, 2015). Climatic variabilities are the types of changes (temperature, rainfall, occurrence of extremes); magnitude and rate of the climate change that causes the impacts on the area of public health, agriculture, food security, forest hydrology and water resources, coastal area, biodiversity, human settlement, energy, industry, and financial services (FAO, 2017). Changes in weather patterns have reduced crop harvest, increased food insecurity and malnutrition as well as poverty (Taneja *et al.,* 2014). Its impact are experienced through an increasing number of seasons without enough rainfall, rainfall peak season ending earlier than normal, poor rainfall distribution within the seasons and change in temperature (Philip *et al.,* 2015). This has direct effect on the timing and duration of crop growing seasons, with concomitant impacts on plant growth.

Climate change affects mainly the agricultural sector and agriculture in turn affects climate change through practices. Agriculture affects climate change through emission of greenhouses gas (GHG) from different farming practices (Adugna *et al.,* 2013). Climate change and agriculture are interrelated processes, both of which take place on a global scale. Climate changes have far-reaching consequences for agriculture that will disproportionately affect small holder farmers. The main impact of climate change is the decline in crop productivity due to change in rainfall pattern and amounts. Livestock production is also a challenge due to lack of good quality grazing grass and lack of drinking water. Greater risk of crops and livestock death is already imposing economic losses, undermining food security and they are likely to get far more severe as global warming continues (Dahal, 2011).

Agriculture is highly vulnerable to climate change. Unreliable precipitation patterns increase the likelihood of crop failure and falls in production of both crops and livestock. In many developing countries, the effects can already be seen as climate change makes the delicate ecosystem balance even more precarious (Gwambene *et al*., 2015). Climate change is causing more frequent and intense periods of drought as overall rainfall levels decline. This results in shorter growing seasons for farmers and in prevalence of pests and diseases in areas where they were not previously a threat to crops.

In countries like Ethiopia and Sudan, climate change has resulted invariability of rainfall, increase in temperature, degradation of natural resources and frequent crop and livestock failures leading to food and nutritional insecurity. Thus, moving agriculture into a more productive and resilient scientific based practice is an urgent need, and it calls for improved management of natural resources (soil, water, land and genetic resources) using conservation agriculture, integrated pest management, agroforestry and sustainable diets (FAO, 2012).

Climate variability coupled with the low agricultural productivity and the low technological and capital base of rural households makes the country particularly vulnerable to adverse effects of climate change. The severity of the impacts of such changes is expected to be more evident in Ethiopian and will affect the poorest and most destitute segments of the population. Some authors have recommended that solutions to these multiple problems may be found by seeking traditional agricultural practices and incorporating them into new, science-based plans for agricultural development. Over generations, local people, especially Ethiopian, developed their own specific natural resource management systems like conservation agricultures, integrated crop and livestock management, irrigation and check dams (Badege et al., 2013).

2.3. Climate change response and agricultural adaptation

Global humanity has endeavored to respond climate change through adjustments in ecological-social-economic systems to actual or expected climatic stimuli, their effects or impacts (IPCC, 2001; Smit & Olga, 2001). Goal of climate change response is centered on building resilience of communities towards different kinds of changes in their environment. Resilience is the capacity to maintain competent functioning in the face of major life stressors (Adger, 2001).

In the sphere of climate change response, adaptation and coping are terms used sometimes interchangeably but could imply different meanings. However, the two are associated with different time scales and represent different processes (Eriksen & Kelly, 2004). Whereas, coping is short term reactive response to climate change variability, adaptation is associated with longer time scales and points at adjustments as fundamental changes of the systems‟ practices, processes or structures due to changes in mean conditions of the surrounding environment. With adaptations, new coping range is established (Smit &Wandel, 2006).

IPCC (2007) recognizes three types of adaptation: First, autonomous or spontaneous adaptations which are unconscious and reactive response to climatic stimuli without intervention with a public policy. The second one is called anticipatory/proactive which refers to adaptation that takes place before the impacts of climate change occur. The third and final is planned adaptation which is based on an awareness that conditions have changed and that action is required to return to, maintain, or achieve a desired state. Whereas planned adaptations are interventional strategies, autonomous adaptations occur naturally without interventions by public agencies (Smit *et al*., 1996). Agricultural adaptation is important in the wake of climate change impacts to achieve food security in the global community. Studies indicate that adaptation can lessen the yield losses that might result from climate change, or improve yields where climate change is beneficial (Adams *et al.*, 1998).

According to Okumu (2013), although relatively inexpensive adaptation strategies such as crop diversification and changing the timing of farm operations, may moderate adverse impacts, the biggest benefits will result from more costly measures including institutional strengthening and technological developments. These adaptation measures alongside other competing interests will require substantial resource allocation by farmers, national and country governments, scientists and development partners.

Studies in Ethiopia indicate that, the dominant adaptation methods practiced by Ethiopian crop producing farmers include use of different crop varieties, tree planting, soil conservation, early and late planting, and irrigation adoption of mixed crop and livestock farming systems and changing planting dates (Nathnael, 2017).

2.4. Concepts of Climate Smart Agricultural Practices

The emerging of CSA can be note to have started after the Hague conference where countries met to discuss the adverse effect of climate change and how to mitigate the effects. This conference led to a number of actions and policies to be implemented in order to achieve its objectives (FAO, 2015). Climate Smart Agriculture (CSA), as defined by FAO at the Hague Conference on Agriculture, Food Security and Climate Change in 2010, contributes to the achievement of sustainable development goals. It integrates the three dimensions of sustainable development (economic, social and environmental) by jointly addressing food security and climate challenges. CSA is composed of three main pillars sustainably increasing agricultural productivity and incomes, adapting and building resilience to climate change and reducing greenhouse gas (GHG) emissions. It is an approach to develop the technical, policy and investment conditions to achieve sustainable agricultural development for food security under climate change (FAO, 2016).

The climate smart agriculture includes many of the field based sustainable agronomic and land management practices such as conservation tillage, agro-forestry, green technology, improved seed and short season variety and others. It is also important to note that climate smart agriculture incorporates integrated planning of land agriculture, fisheries and water use at different scale such as local, watershed and regional, etc. (Melaku *et al*., 2016). CSA seeks to increase productivity in an environmentally and socially sustainable way, to strengthen farmers‟ resilience to climate change and to reduce agriculture’s contribution to climate change by reducing GHG emission and increasing soil carbon sequestration (FAO, 2010; World Bank, 2011).

The climate smart agriculture (CSA) concept reflects an ambition to improve the integration of agriculture development and climate responsiveness. It aims to achieve food security and broader development goals under a changing climate and increasing food demand. CSA initiatives sustainably increase productivity, enhance resilience, and reduce/remove greenhouse gases (GHGs) and require planning to address trade-offs and synergies (co-benefits and "triple-wins") between these three pillars productivity, adaptation, and mitigation (FAO, 2013).

The general conceptual framework of CSA which integrates policies around the triple objectives to improve food security, increase resilience and decrease GHG emissions wherever possible is presented in Figure 1.

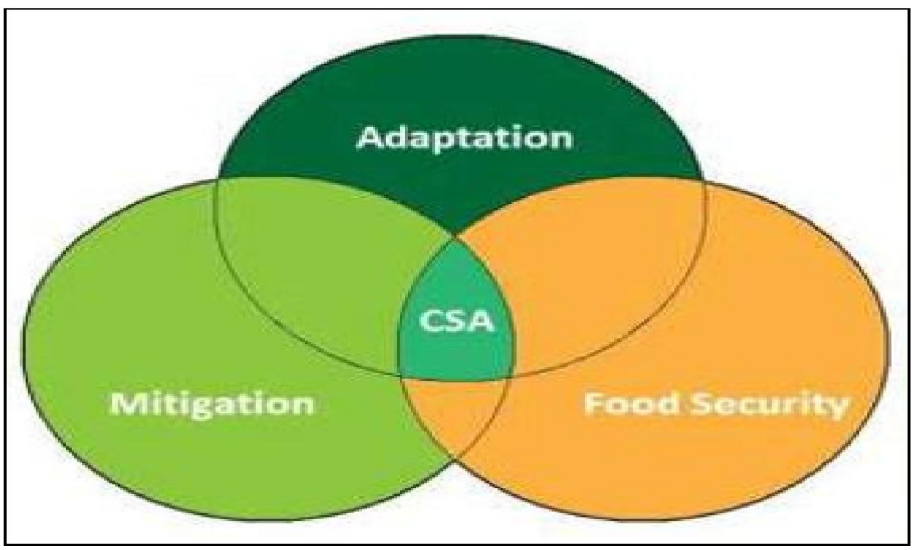

Figure 1: The Conceptual Framework for CSA

Source: CSA Source Book, 2013

2.5. Climate Smart Agricultural Practices in Ethiopia

Ethiopia actively promotes the use of CSA to assist farmers improve their livelihoods and buffer against climate variability and climate change (Jirata *et al*., 2016). According to FAO (2013) there are a wide range of agricultural practices and approaches that are currently available at the field level that can contribute to increased production while still focusing on environmental sustainability. The role of these technologies and practices in reducing current as well as future climate change impacts on agriculture and decreasing GHG emission intensity are crucial.

CSA practices in Ethiopia include sustainable land management, conservation agriculture, agroforestry, reforestation, planting tree, composting, integrated watershed management, small scale irrigation, crop rotations, intercropping and promotion of improved livestock feed. Agroforestry and conservation agriculture are climate smart agricultural practices because of the fact that they contribute to increasing food security and they raise climate adaptation in sustainable way (Hailemariam *et al.*, 2016). As one of the climate smart agriculture approaches, integrating trees into the agricultural systems (cropping, pastures, fences or home gardens) agro forestry has already proven to be an effective strategy to protect arid areas against land degradation and reduction of biomass (Joseph, 2014). In terms of greenhouse gas emissions, agroforestry is generally recognized as the climate smart agriculture practice with the greatest potential for contributing to climate change via high carbon sequestration in tree species and in the soil (Branca *et al*., 2011).

The agroforestry practices intended to address issues of soil erosion and diversification of farm produce as well as agricultural yield, resilience to climate variability (for example through provision of shade during hot spells) and creation of favorable microclimates for certain crops. Integrating perennial trees or shrubs in agricultural lands used both for crop production and grazing in Ethiopia has been documented to improve soil cover and ensure green cover during the off-season (Kitalyia *et al*., 2011).

Many areas of Ethiopia are mountainous and the crop fields are rarely flat often they are located in a hill side or in a valley side. This creates extra demand for soil and water conservation to prevent the soil and rainwater from being washed away. The structures for soil and water conservation, which include terraces, bunds, contour cultivation, grass strips, check dams. The goal of all these structures is to reduce run-off and soil erosion, which can help to increase yields, especially on steeply sloped land (Obalum *et al*., 2011). Tree planting is also the major climate smart agricultural practice used by farmers in Ethiopia. Vegetation like trees, plants, and grass are valuable because the roots protect the soil from erosion. Trees are valuable during floods and droughts, and many trees together might give lower temperatures in the near area, a more fresh air, and also shadow and maintaining soil fertility, providing timber and supplementary feed for livestock, fodder trees were specifically planted as supplement feed for livestock (Julius *et al*., 2013).

Irrigation is technology that can have a huge impact on insulating farmers from climate shocks, but which also tends to be used more by larger farmers and on an industrial scale. It reduces farmers' reliance on natural rainfall patterns, which in general reduces vulnerability to climatic variation. There are a number of different irrigation systems, including surface (flood or canal/furrow), sprinkler, and drip irrigation (surface or sub-surface). The source of irrigation water also comes from many different sources, including hand-drawn or pumped well water, water diverted from natural rivers, or water delivered via diversion canals from manmade reservoirs or run-off catchment structures (McCarthy, 2014).

An integrated crop-livestock management is vital to enhance livestock production and safeguarding the environment through prudent and efficient resource use, excreta contains several nutrients (including nitrogen, phosphorus and potassium) and organic matter, which are important for maintaining soil structure and fertility. Through increased production is while the risk of soil degradation is reduced. Excreta are also the basis for the production of biogas and energy for household use (e.g. cooking, lighting) or for rural industries (e.g. powering mills and water pumps). Integrated crop and livestock systems, at various levels of scale (on-farm and area-wide) increase the efficiency and environmental sustainability of both production methods. When livestock and crops are produced together, the waste of one is a resource for the other. Manure increases crop production and crop residues and by-products feed animals, improving their productivity. In these systems, integrated crop livestock is a strategic element for climate smart agricultural practices (Alexandre and Vincent, 2012).

Manure management is important to alleviate climate change as it can be used as organic fertilizer and is also a source of methane (CH4) and Nitrous Oxide (N2O) emissions. When manure is used as organic fertilizer it contributes to the productivity and fertility of the soil by adding organic matter and nutrients. It improves productivity and allows for reductions in use of synthetic fertilizers and the associated direct and indirect GHG emissions (Gerber *et al*., 2010). The increasing geographic concentration of livestock production means that the manure produced by animals often exceeds the absorptive capacity of the local area. Manure becomes a waste product rather than being the valuable resource it is in less concentrated, mixed production systems. Proper use of technologies can reduce direct emissions and also transform manure into a valuable resource and lead to a corresponding reduction in GHG emissions resulting from the use of synthetic fertilizers (Burney *et al*., 2012).

Table 1: Some common CSA practices in Ethiopia

CSA practice	Components	Why it is climate smart
Conservation agriculture	• Reduced tillage • Crop residue management –mulching, intercropping • Crop rotation/intercropping with cereals and legumes	• Carbon sequestration • Reduce existing emissions • Resilience to dry and hot spells
Integrated soil fertility management	• Compost and manure management, including green manuring • Efficient fertilizer application techniques (time, method, amount)	• Reduced emission of nitrous oxide and CH4 • Improved soil productivity
Small-scale irrigation	• Year-round cropping • Efficient water utilization	• Creating carbon sink • Improved yields • Improved food security
Agroforestry	• Tree-based conservation agriculture • Practised both traditionally and as improved practice • Farmer-managed natural regeneration	• Trees store large quantities of CO2 • Can support resilience and improved productivity of agriculture
Crop diversification	• Popularization of new crops and crop varieties • Pest resistance, high yielding, tolerant to drought, short season	• Ensuring food security • Resilience to weather variability • Alternative livelihoods and improved incomes
Improved	• Reduced open grazing/zero grazing	• Improved livestock

livestock feed and feeding	• Forage development and rangeland Management • Feed improvement	productivity • GHG reduction • CH_4 reduction

(Adapted from FAO, 2016)

Practicing crop rotation and intercropping has many advantages, which include reduced risk of pest and weed infestations; better distribution of water and nutrients through the soil profile; exploration for nutrients and water of diverse strata of the soil profile by roots of many different plant species, resulting in a greater use of the available nutrients and water; increased nitrogen fixation through certain plant -soil biota; and increased formation of organic matter (Ketema and Bauer, 2012). Better nutrient management through crop rotation can decrease nitrogen fertilizer, substantially lowering related greenhouse gas (GHG) emissions (nitrous oxide has a global warming potential 310 times greater than CO_2). Reduced synthetic fertilizer use also leads to reduced greenhouse gas emissions from the manufacturing process and transportation (PANW, 2012). In Ethiopia various projects and programmes are implemented in the different agro-ecological zones of the country. This programs and projects includes Climate-Smart Initiative for PSNP and HABP, Farm Africa and SOS Sahel, PSNP-PW, Reducing Emissions from Deforestation and Forest Degradation (REDD+), Enhancing income of smallholder farmers through integrated soil fertility management, Humbo Assisted Natural Regeneration Project (Afforestation and Reforestation), Agricultural Growth Project (AGP), Sustainable Land Management (SLM) Programme etc.

2.6. Agricultural Growth Program (AGP) Project

Agriculture sector of Ethiopia has been striving to enhance economic growth especially in the GTP-I period. In the same period, overall economy has been growing at the rate of 11% per annum for which AGP has also been one of the development initiatives that made substantial contributions. AGP is a multifaceted investment program supporting agricultural productivity and commercialization focusing on high agricultural potential areas to address some of the key constraints to agricultural growth and thereby contribute to overall economic growth and transformation. It is a program approach, which is being viewed as one of the key investment mechanisms for development partners and government to collaborate on (Agajie *et al*., 2018).

Increased agricultural productivity and commercialization and in particular the increase in related upstream and downstream economic activities that are part of this development can also provide some employment opportunities for the many "landless youth" in Ethiopia as well as creating export growth. Similarly, the big environmental challenges that Ethiopia faces due to degradation of productive land and increasing climate variability can only be addressed through higher productivity of crop and livestock production in those areas where it can be done sustainably (Agricultural Growth Program, 2010).

Following completion of AGP-I, the Second Agricultural Growth Program (AGP-II) was made to be aligned with GTP II, there by contributing to the achievement of targets set for the growth of agriculture sector. AGP-II was designed based on the lessons and best practices of AGP-I to improve implementation and maximize the overall impact of the program. The overall objective of AGP-II is to increase agricultural productivity and commercialization of smallholder farmers targeted by the Program and also contributes to dietary diversity and consumption at household level. The project would also contribute to the higher-level objectives of poverty reduction, and climate change mitigation and adaptation through supported climate smart agriculture initiatives (Agajie *et al*., 2018).

2.7. How can CSA address food security?

The concept of food security has been used extensively at the household level as a measure of welfare. A household is considered food secure if all members at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Climate change disrupts food markets, posing population wide risks to food supply. Increasing the adaptive capacity of farmers as well as increasing resilience and resource use efficiency in agricultural production systems is paramount (FAO 2013). Indeed climate change alters agricultural production and food systems, and thus the approach to transforming agricultural systems to support global food security and poverty reduction is through CSA.

CSA prioritizes food security with a consideration of mitigating climate change (Lipper *et al*., 2014). An integrated, evidence based and transformative approach to addressing food and climate security at all levels is required. It calls for a coordinated action from the global to local levels, from research to policies and investments, and across private, public and civil society sectors to achieve the scale and rate of change required. Through Climate Smart practices, more efficient resource use agricultural production systems offer considerable potential for increasing agricultural productivity, incomes, food security and the resilience of rural livelihoods while reducing the intensity of agricultural emissions (FAO, 2010). With the right practices, policies and investments, the agriculture sector can move into CSA pathways, resulting in decreased food insecurity and poverty in the short term while contributing to reducing climate change as a threat to food security over the longer term.

2.8. Crop Production through Irrigation Practice

Crop production is function of water, nutrient, climate and soil environment (Gebremedhin and Peden, 2002). Provided that all other requirement are satisfactorily for proper growth and production, rainfall rarely meets the time with required amount of water application for plant growth. As result average yield of agricultural crops under rain fed agriculture is low compared to irrigated land. The average crop yields per hectare from irrigated land increases 2.5 times higher than the yield produced by rain fed agriculture (Kalkidan and Tewodros, 2017). Higher productivity helps to increase returns to farmers' endowment of land labor resources and produced more than twice per year (Dereje *et al*., 2011). This implies that switching from subsistence production to market oriented production. Despite its economic and social benefits, production and productivity of different agricultural crops in Ethiopia are mostly on a small-scale and average crop yield is very low, as compared to other developing countries (Seleshi *et al*., 2010). To increase productivity and diversify the livelihood scenarios as an option, development of small-scale irrigation schemes has been introduced through water harvest technology (Hussain and Hanjra, 2004). Irrigation is an important strategy in reducing risks associated with both rainfall variability, production of different crops twice or three times within a year and increasing income of rural farm-households (Fitsum *et al*., 2009).

2.9. Factors influences the adaptation of implemented agricultural practice by AGP

Socio-economic factors that influence adoption of adaptation strategies include household characteristics and farm characteristics. The household characteristics that can potentially influence adoption decisions include age, education level, gender of household heads, family size, and land holding size of households, active labour force and livestock holding of household heads. The age of a farmer may positively or negatively influence the decision to adopt new technologies (Gbegeh & Akubuilo, 2013). Older farmers have more experience in farming and are better able to assess the characteristics of modern technology than younger farmers, and hence a higher likelihood of adopting the practice. On the other hand, older farmers are more risk averse and less likely to be flexible than younger farmers and thus have a lesser likelihood of adopting new technologies (Adesina & Forson, 1995). According to Ayuya *et al*. (2012) attitude towards risk both influence the decision on willingness to accept and the extent of adoption. The explanation is that farmers who are risk taking would be willing to adopt the project to a larger extent than those who are risk averse. Education level is often assumed to increase the likelihood of embracing new technologies as it enhances the farmer's ability to recognize the effects of climate change (Nkonya *et al*., 2008). Similarly, education enables households to access and conceptualize information relevant to making innovative decisions (Adesina & Forson 1995). However, higher educational attainment can present a constraint to adoption because it offers alternative livelihood strategies, which may compete with agricultural production.

The effect of gender of household head on adoption decisions is location-specific culture driven (Gbetibouo, 2009). The possible reason for this observation is that in most rural smallholder farming communities in Africa, more women than men live in rural areas where much of the agricultural work is done. Farmer's wealth has a significant influence on ability of smallholder farmers to adopt certain technological practices (Nkonya *et al*., 2008; Gbetibouo, 2009). Households with higher income and greater assets like land and other valuable movable assets are less risk averse than lower income households, and therefore are better placed to adopt new farming technologies (Shiferaw & Holden, 1998).

The influence of household size on the decision to adopt new farming techniques in response to climate change is uncertain. Household size as a proxy to labor availability may influence the adoption of a new technology positively as its availability reduces the labor constraints (Marenya and Barrett, 2007). Given that the bulk of labor for most farm operations in Sub-Saharan Africa is provided by the family rather than hired, lack of adequate family labor accompanied by inability to hire labor can seriously constrain adoption practices (Nkonya *et al*., 2008). Nonetheless, households with many family members may be forced to divert part of the labor force to off-farm activities in an attempt to earn income to ease the consumption burden imposed by larger household size (Tizale, 2007; Gbetibouo, 2009). Farm characteristics could also influence adoption decisions and they include farm size and soil fertility, soil erosion and slope of land. Farm size influences both the access to information and the adoption decisions (Marenya & Barrett, 2007; Gbetibouo, 2009). Soil fertility may influence adoption of recovery practices.

On the other hand, institutional factors could also influence adoption of new technologies and they include; access to credit, access to information, off-farm employment, land ownership, group membership and government policies (Adesina & Forson, 1995; Gbetibouo, 2009). Adoption of new farming strategies require funds and lack of borrowing capacity may limit ability of farmers to embrace adaptation measures that require heavy investment for instance in strategies like irrigation, terracing, tree planting soil testing and fertilizer use (Gbetibouo, 2009). Similarly, farmer to farmer extension and information sharing about future climate change may enable them to adjust their farming practices in response to climate change (Smit *et al*., 2001; Gbetibouo, 2009).

Land ownership has an implication on the property rights and long term investment in climate change adaptation strategies. For instance, tenure security can contribute to adoption of technologies linked to land such as irrigation equipment or soil conservation practices. Farmers lack economic incentives to invest their time or money if they cannot capture the full benefits of their investments (Gbetibouo, 2009). Off-farm employment may provide alternative sources of income to the household hence limiting dependence on agriculture and may further lower the chances of climate change adaptation. Government extension service officers target farmer groups for demonstration of new technology. Finally, government policy on climate change could set conditions for agricultural operations to be observed as a rule. Hence farmers may be mandated to perform conservation agriculture within the legal framework (Smit *et al*., 2001; Gbetibouo, 2009).

2.10. Conceptual Framework

The conceptual frame work acts like a map that gives coherence to empirical inquiry (Shields and Tajalli, 2006). Agricultural technology is generally based on the expected benefit derived from technology practice, where farmers are assumed to maximize their benefit from the practices of agriculture. Different climate smart agricultural practices are adopted by various farmers, which enhance the farmer's response to climate change.

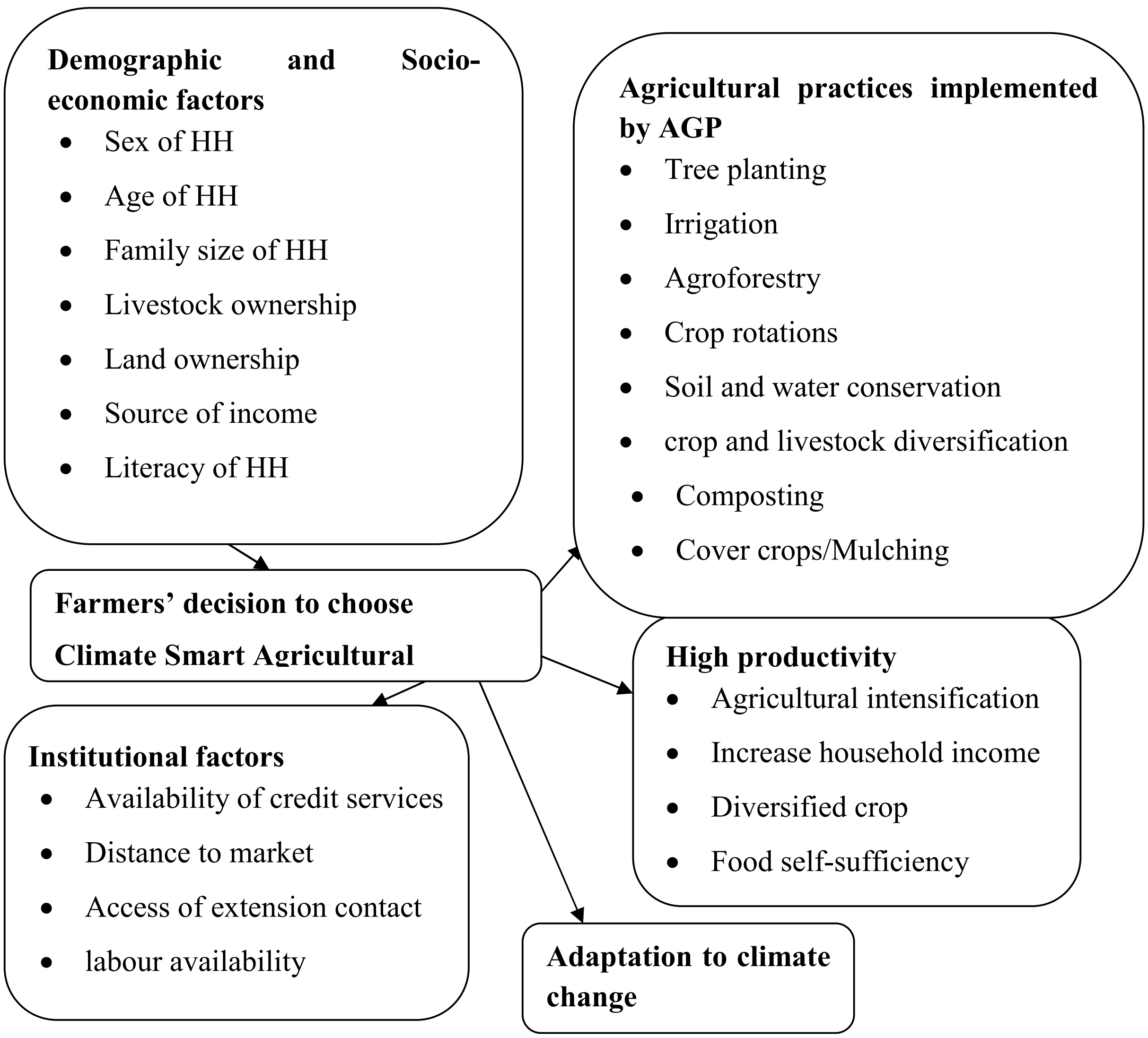

Figure 2: Conceptual framework of the study

However, adoption of climate smart agricultural practice influenced by socio -economic, demographic and institutional characteristics of the farmers (Figure 2). Demographic characteristics such as age, total members of household, sex and literacy of household, and socioeconomic characteristics such as land and livestock ownerships of the household and income of household affects farmer decision provide by agricultural growth program (AGP) to adopt climate smart agricultural practices. Institutional factors that affect farmer's decision to adopt implemented agricultural practice by AGP includes availability of credit and infrastructure, access of agricultural extension agents, access of information on climate change, and participation of farmers in social and labour organization of the community. It is based on the above assumptions that the data will be gather from survey respondents, interviewees and key informants are analyze.

3. MATERIALS AND METHODS

3.1. Description of study area

3.1.1. Geographical location of study area

The study was conducted in Efratana Gidm District which is one of the 24 Districts of North Shewa of Amhara Regional state, Ethiopia. The administrative center of Efratana Gidm District is Ataye town, which is located about 139 kilometers from the zonal capital city, Debire Birehan and 273 km from Addis Ababa along Dessie road. Efratana Gidm District lies between 10° 5’N-10^{0}32’N and 39° 50’E- 39^{0} 0’ E latitude and longitude respectively (Figure 3). The study area covers the total area of 51685.5ha. It is bordered Kewot District in the South, Menz Mama District in the Southwest, Menz Gera District in the West, Antsokia Gemza District in the North and Oromia Zone in the East. The district covers a catchment area of 516.85km^2, which comprises a total of 19 rural and 2 urban kebeles administrative (EGDOA, 2019).

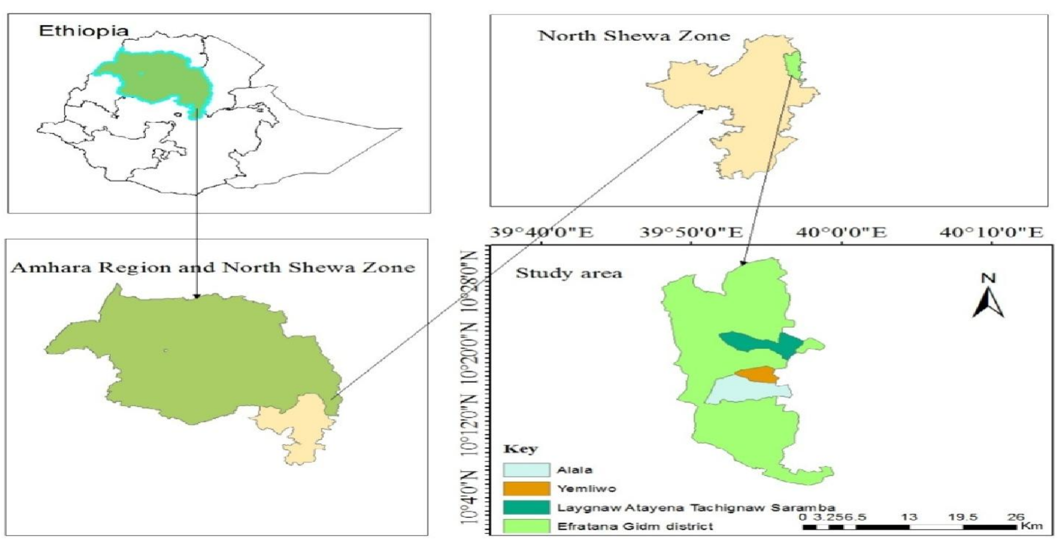

Figure 3: Geographical location of Efratana Gidm District

3.1.2. Topography and land use type

The topography of the district is generally rugged and broken, with many hills and ridges, making most area unsuitable for agriculture, even though cultivated. Some 37% of the district is mountainous, 21% is rugged terrain and 42% is plain lands.

Efratana Gidim District has also different land use patterns, which is supporting the livelihood of the inhabitants in different ways. The major land use pattern of the district types includes croplands 47%, forest and bush 23%, and grazing 10% (EGDOA, 2019).

3.1.3. Vegetation cover and Water resource

The natural vegetation of the area, like other parts of the country, has been influenced by human activities. Major reason for this rapid decline of forest coverage is due to extensive deforestation, due to the population growth and expansion of cultivation land. The district is well known by its underground and surface water like rivers and streams. Nazero, Jewuha and jara are the three big rivers known in the Woreda (EGDOA, 2019).

3.1.4. Demographic and socio-economic activities

Based on the 2007 national census conducted by the Central Statistical Agency of Ethiopia (CSA), this district has a total population of 110,493, an increase of 9.94% over the 1994 census, of whom 55,672 are men and 54,821 women; 15,319 or 13.86% are urban inhabitants. A total of 26,239 households were counted in this district, resulting in an average of 4.21 persons to household, and 25,427 housing units. Religious and ethnic compositions are the major components of demographic feature of a nation, in the district is 98% of the population are Amhara, 0.9% are Oromo, 0.2% are Argoba and 0.4 are other Ethiopian ethnic origin and most 88% of the population is Ethiopian Orthodox religion follower followed by Muslim 10.99% and Protestant 0.53%.As common in many parts of Ethiopia, agriculture is the main income source of population in the study area. It involves subsistence rain fall cultivation of crops and livestock production. The dominant crops in the area coverage, production and consumers number in the study area are cereal, pulse and oil crops such as Sorghum (sorghum bicolor L.), Teff (Eragrostis teff), Maize (Zea mays), Mungbean, Haricot bean and Onion are common and cultivated for house hold consumption and income source. With regard to livestock, cattle, goat, sheep, camel, donkey and poultry are common.

3.2. Research design and methodology

3.2.1. Sampling technique and sample size determination

A multi-stage purposive and random sampling technique was used for this study. In the first stage, the study area, Efratana Gidm District, was purposively selected based on the availability of agricultural growth program implemented agricultural practices. In the second stage, among the total 19 rural kebeles three kebeles namely Tachignaw Saramba Lay Ataye, Yimlow and Alala were selected based on simple random sampling method. In the third stage, within the selected three kebeles households who have their own land and participate in agricultural growth program were considered. Then simple random sampling techniques were used to select households. The sample size was determined using the formula developed by Kothari (2004).

Determination of the sample size was based on the formula given as shown below:

$$n=\frac{Z^2 * p * q}{d^2} \text{........... Equation (1)}$$

Where; n is the sample size, z is 95% confidence level (α= 0.05) is 1.962 = 4, p is the proportion of the population of interest, smallholder farmers. Variable q is the weighting variable and this is computed as 1-p, and d is an acceptable error (precision). P was set to 0.5 since statistically, a proportion of 0.5 results in a sufficient and reliable size particularly when the population proportion is not known with certainty. This led to q of 0.5 (1- 0.5). An error of less than 10% is usually acceptable (Kothari, 2004) thus; the study took an error of 0.07 to approximate a sample size of 204 household survey respondents. (i.e. 4*0.5*0.5/0.072 =1/0.0049 = 204)

Finally, total 204 sample households were selected simple random sampling using probability proportional to size sampling technique.

Table 2: Sample household distribution of the selected kebeles

Kebele	Total HHs	AGP Adopters			AGP Non-adopters			Total Sampled HHs		
		M	F	T	M	F	T	Male	Female	Total
TachSaramba	831	34	3	37	12	1	13	46	4	50
Yimlow	984	41	2	43	15	2	17	56	4	60
Alala	1548	54	5	59	29	6	35	83	11	94
Total	3363	129	10	139	56	9	65	185	19	204

Source: Own computation (2020)

3.3. Data Sources and Methods of Data Collection

Both quantitative and qualitative data were collected from primary as well as secondary sources. Primary data were collected from key informants (KIs), focused group discussions (FGDs) and household (HH) survey. Secondary data were obtained from relevant published and unpublished data sources. Qualitative data were used to capture information pertaining to local households' perception and opinions on climate smart agricultural practices and agricultural growth program project issues using key Informant Interviews and Focus Group Discussions. The questionnaire was refined and finalized after incorporating the inputs of the survey. One supervisor and twelve enumerators were trained to collect relevant data from sample households, on how to record the responses, and on detailed contents of the questionnaire before the start of the main survey.

3.3.1. Primary data sources

Household survey: Questionnaires were used to interview the sample household. The questionnaires were first prepared in English and translated into the local language known as "Amharic". The questionnaire were designed to collect data on household characteristics, resource endowment, climate smart agricultural practices implemented, sources of income, types of crops grown and their production. The questionnaire was pre-tested and adjusted as per the response. Finlay, enumerators who have a certificate in agriculture and natural resource areas were recruited from the three kebele and trained for one day on how to collect data and contents of the questionnaire. The enumerators were monitored by the researcher.

Key Informant Interview (KII): Key informants (KIs) are those people who are knowledgeable about the area and the major issues of the study (Elder, 2009).

For this study, KIs are peoples who are knowledgeable and understanding about the existing trend of climate change, the socioeconomic status of small holder farmers, livelihood activities of the communities, the contribution of agricultural growth program for increasing agricultural productivity and household incomes, types of agricultural practices supported by agricultural growth program project and its role to climate change adaptation in the area and have certainly lived in the area long enough to clarify the issue of interest. The key informants were held with Development Agent (DA), model farmers, female headed household, Woreda agricultural officials and Kebele officials. In general, 15 (fifteen) KIs were selected in order to obtain information for a sort of data triangulation. The key informants were individually interviewed on the overall information that has risen as criteria.

Focus Group Discussions (FGD): In a focus group discussion, a group of people having similar concerns and experience regarding a subject are encouraged to participate. Focus group discussions (FGD) with development agents, district agricultural development office irrigation experts, agronomic experts, AGP focal person and agricultural growth program beneficiary farmers to gather qualitative data were conducted. The FGD considered 6-12 individuals per kebele (Elder, 2009). Therefore, one FGD in each sample kebeles that make up a total of three FGDs which have 24 participants. The discussion was facilitated by the researcher together with the enumerators based on the designed check list. The purpose of the focus group discussions was to generate in depth information on some of the survey findings and other issues that may not have been adequately captured by the structured questionnaire survey.

Field Observation: Observation entails gathering data through vision as its main source; it is a method by which information is required by way of investigators on observation without asking from respondents (Kothari, 2004). Accordingly, the study area was observed before and during the study period. Prior to collecting data, the study areas were visited to know the types of services farming household's access from the agricultural growth program (AGP). In order to handle the most pertinent information, transect walks with the researchers, Development agents (DAs), model farmers, kebele leaders across the small scale irrigation practice area and climate smart agricultural landscape areas were conducted.

3.3.2. Secondary data source

Secondary data collection was done through published and unpublished documents from the published documents like literature, previous studies, books, journals, and the unpublished document was obtained from both regional and district office reports from the study area, including reports on weather and demographic data. The information includes detailed data with regard to agriculture and climate change, source about climate change problems and climate smart agriculture practices in country level and local level (study area), description of the study area, rainfall and temperature data and population data, related research findings.

3.4. Data analysis

After the data were collected from the sample respondents, descriptive, inferential statistics and econometric model were used for analyzing the quantitative data. The data were analyzed using Statistical Package for Social Science (SPSS version 25), Microsoft Excel

2013and specific characteristics of the variables and results were presented in tables and graphs. Binary Logistic regression model was used to analyze the factors influencing farmer's choice of agricultural practices implemented by AGP in the study area.

3.4.1. Descriptive statistics

Descriptive statistical tools such as frequency distribution, mean, maximum, minimum, standard deviation and percentage were used to analyze the quantitative data. These descriptive analyses were used to identify types of agricultural practices commonly used in the study.

Inferential statistics such as Chi-square(X^2) was used to identify the association between categorical variables and independent t-test was used to test significant mean proportion differences between categories dependent variables in terms of different explanatory variables, while taking the research objective take in to consideration. Data that obtained from KIs and FGDs and other qualitative data were analyzed in qualitative way.

3.4.2. Econometric analysis

Econometric model was adopted to assess factors influencing farmers' adaptation of agricultural practices implemented by AGP for climate smart agriculture in the study area. According to Gujarati (2004) logistic regression model use when the dependent variable is dichotomy and the independent variables are of any type. It also shows that binary logistic regression is preferred for the dependent variable which have binary outcome that is easy to interpret and provides odds ratios.

Binary logistic regression model was applied to analysis parameters of binary logistic regression model for factors influencing the adaptation of agricultural practices implemented by AGP. The dependent variable is agricultural practice implemented by AGP participation which is a qualitative variable (nominal) that the values were either yes or no (binary outcome). This dependent variable may affected by different socio economic and farm specific characteristic. The functional form of logit model is specified as follows:

$$P_i = E(y = \frac{1}{xi}) = \frac{1}{1 + e^{-(Bo+BiXi)}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

For ease of exposition it can write Equation (1) as $P_i = \frac{1}{1 + e^{-zi}}$ .... (2)

The probability that a given household is AGP adopter is expressed by (2), while the probability for non-users.

$$1 - P_i = P_i = \frac{1}{1 + e^{zi}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Therefore it can be written as

$$\frac{Pi}{1-Pi} = \frac{1+e^{zi}}{1 + e^{-zi}} = e^{zi} \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Now ($\frac{Pi}{1-Pi}$) is simply the odds ratio in favor of participation to agricultural practice implemented by AGP, the ratio of the probability that will be non-users. Finally taking the natural log of equation (4) it obtains:

$$L_i = \ln [\frac{Pi}{1-Pi}] = z = B_0 + B_1X_1 + B_2X_2 + B_kX_k \quad \text{where } X_1, X2 + \ldots + X_k \ldots\ldots\ldots (5)$$

Where Pi is the probability being agricultural practice implemented by AGP adopter ranges from 0 to 1.

Zi= is a function of n- explanatory variables (x) which also expressed $Z_i = B_0 + B_1X_1 + B_2X_2 +$ BkXk, B_0 = intercept, B_1, B_2….. B_k slopes of the equation in the model.

L_i = is log of the odds ratio, which is not only linear in x_i but also linear in parameters. X_i = is vector of relevant household characteristics. If the disturbance term (u_i) is introduced, the logit model becomes:

$$Z = B_0 + B_1X_1 + B_2X_2 + B_kX_k \quad \text{where } X_1, X2 + \ldots + X_k + U_i. \qquad (6)$$

Multicollinearity test was applied before estimating the model between explanatory variables to meet the assumption of Classical Normal Linear Regression Model (CNLM). Due to this, variance inflation factor for continuous and contingency coefficient test for dummy variables association was tested.

$$VIF = \frac{1}{TOL} = \frac{1}{1-R_i^2} \text{ --- } (1)$$

Where VIF = variance inflation factor, TOL= tolerance which is the inverse of VIF, $R_i^2$is coefficient of determination in the regression of one explanatory (x_i) on other explanatory variable (x_j). As a rule of thumb**,** if the VIF of a variable exceeds 10, which will happen if R_i^2 exceeds 0.90, or if tolerance close to zero that the variable is said be highly collinear (Gujirati, 2004). To avoid a serious problem of multicollinearity, it is quit essential to omit the variables with VIF exceeds 10 in case of continuous variables.

$$CC = \sqrt{\frac{x^2}{N+x^2}} \text{ --- } (2)$$

Where CC = contingency coefficient, X^2 = chi-square, N = total sample size. If contingency coefficient test value exceeds 0.8 for those dummy variables, there is a multicollinearity problem (Gujirati, 2004).

Hypotheses and Definition of Variables

Since the analytical procedures and their requirements are known, it necessary to identify the potential variables and describe the measurements. Accordingly, the variables will be expected to have influence on agricultural growth program implemented agricultural practices participation and effects on climate smart agriculture are explained below.

Dependent variables

Household participation of agricultural practices implemented by AGP (1 for adopter and 0 for non-adopter) was investigated as dependent variable. Based on the review of the literatures and practical experiences, explanatory variables which have logical and justifiable rational in determining household participation to AGP are identified. These are presented as follows:

Age of a household head (AGE): Age is a continuous variable measured in years that determine the CSA adoption and household income. According Diederen *et al*. (2002) the younger the farmer, the more likely to adopt new technology early. Hence, the expected effect of age on household decision to participation of AGP could be positive or negative.

Gender of the household head (SEX): This is a dummy variable with 1 for male and 2 otherwise. In Ethiopia, household head is the decision maker for farm activities. Male household heads are expected to decide for participation of AGP and have higher income compared to female household heads because of better labor inputs used in male-headed households (Kipkoech *et al*., 2015). Hence it is expected to be positive or negative.

Education level of a household head (EDUC): The level of education can enable the household to be open to receive, understand and implement the information relevant for the adoption of a new technology. It is a categorical variable and measured by grade level of the head of the households. Education status was therefore expected to positively correlate with adoption of technology, that is rate of adoption is supposed to be higher with the increases of level of education (Farid *et al*., 2015).

Household size (HHSZ): represented the total number of family members residing in a home together at the time of the study For farming activity, an able body is a necessary condition in the family in order to fulfill the household consumption. A household who has more number of family members could share the work load to them and contribute a lot to the income of the specific household. In this study, if the majority of the family members are including active labor force age, the household will have enough labor force and the probability to use agricultural practices is increase. Hence it is expected to influence the adoption of AGP of the household positively (Abrham *et al*., 2017).

Access to extension service (EXTEN): It is a dummy variable which takes a visiting time by extension agent. Extension services are an important source of information on farming system and technical support in the context of climate smart agriculture practices and climate change. This implies that farmers with more access to information and technical assistance on agricultural activities have more awareness about the contribution of AGP for climate smart agriculture. More frequent DA visits, using different extension teaching methods like attending demonstrations and field day can help the farmers to adopt AGP. However, all farmers may not have equal access to extension services. Some farmers visit extension agents more frequently while others visit rarely. If the farmers get better extension services, they are expected to adopt agricultural practices implemented by AGP than others. The extension service expected to have a positive effect on agricultural practices implemented by AGP.

Access to Credit Service (CREDIT): The ability of a household to obtain finance either as formal credit or semi-formal credit, which includes consumption credit (Iftikhar, 2017). It is taken as a dummy variable; if the respondent has access to credit they will code with a numeric value 1, and 0 if otherwise. Credit can help ease cash constraints and allows farmers to buy purchased inputs such as improved seed, Fertilizer, chemicals, livestock feed, and farm equipment (Malefiya, 2017). Thus, this study hypothesized that there is a positive relationship between access of credit and adoption of agricultural practices implemented by AGP.

Distance of the farm field from homestead (FARMDIST): This variable is a continuous variable represented by walking time (in hours) from farmers' residence/home to their farming place. It considers this as possible factor in farmers' decision to undertake adoption agricultural practices implemented by AGP. We expect that the farmer whose farm is far from his residence is less likely to continuously follow up his farm as compared to those whose farm nearer to their home. Thus, it is expected that farmers who live near to their farm are likely to have regular follow up of their farm, hence motivated to implements agricultural activities. Thus, this variable expected to have a negative sign.

Distance to market (DISMKT): It is a continuous variable measured in kilometers or hours from the residence of farm household to the market area. Distance to the nearest market, as expected, negatively affects the adoption decision for all inputs; the distance constitutes indeed a constraint on the time that farmers can devote to accessing information and inputs, which in turns determines the cost of production. The residences of farmers 'are nearest to the market they get a lot of opportunities as compare to the far ones (Malefiya, 2017). Therefore, this is variable will have a negative sign for the contribution of AGP implemented agricultural practices for climate smart agriculture.

Farm size (LANDSZ): This is a continuous variable measured in hectares. Large land sizes al low farmers to diversify their crop and livestock options and help spread the risks of loss associated with changes in climate (Farid *et al*., 2015). Therefore, this study hypothesized that land holding has positive relation with implementation of agricultural practice by AGP.

Total Livestock Holdings (TLU): This refers to total number of livestock measured in tropical livestock unit (TLU). Livestock is important source of income, food and draught power for crop cultivation in Ethiopian agriculture. Households with more number of livestock have a chance to obtain more direct food or income to purchase foods commodities, particularly during food crisis. Therefore, higher livestock size would significantly increase the household participation to agricultural practices implemented by AGP that enables to increase status of income (Lemmi *et al*., 2013; Tessema *et al*., 2013; Aschalew, 2014).

Income of Households (INCOME): Income is a return to farmers from their investment in terms of their labor, time, land and capital among others. This is a continuous variable and shows the amount of income the farmers make per year from their farm and non/off farm. It is measured in Ethiopian birr. Here it is believed that the more the farmer's income from farm the more likely are the farmer to adapt to climate change by devoting their time and money for this activity. The farmers who don't get sufficient return from their farm they can even shift their labor to off-farm activities. Thus, this variable expected to have a positive sign.

Off-farm income (OFFARMI): represents the amount of income generated from activities other than crop and livestock production. It is a dummy variable and measured the household head income. It is expected that the availability of off-farm income is positively related with implement agricultural practice by AGP.

Table 3: Description of hypothesized variables in the binary logistic model

variables	Type of variable	Description of variables	Expected sign
Age	Continuous	Age of household head in year	Negative
Sex	Dummy	1if household head is male 2, female	Positive/Neg.
Education	Categorical	Education background of household head (1=Illiterate,2= Read and Write (1-4), 3= Secondary school (5-8), 4 = High school, above	Positive
Family size	Continuous	Total number of family member in the household	Positive
Extension contact	Categorical	1if household have access to extension service ,0 otherwise	Positive
Credit access	Dummy	1if household have access to credit ,0 otherwise	Positive
Market distance	Continuous	Time taken in hour from market center	Negative
Land size	Continuous	Total land size households in hector	Positive
Livestock	Continuous	Livestock ownership in TLU	Positive
Income	Continuous	Total household income in birr	Positive
Labor force	Continuous	Labor of house hold members	Positive
Off-farm activity	Dummy	1, if the household has sources of off-farm income, 0 otherwise.	Positive
Farm distance	Continuous	Farm distance from home (walking hours on foot)	Negative

Active Labor force in the family (LABOR): Number of active labor force in the family indicates the excess of household size over the children under the 15years of age and the elders over the 65 years of age and institutionalized household members. It is a continuous variable and is assumed to represent the working labor input to the farm. As the size of the active labor force in the family increased, the amount of human capital will increase which in turn increase the farmers' willingness for implement agricultural practice by AGP and taking climate change adaptation measures which needs labor force like conservation of soil and water and others. This variable is included in this study to ascertain if it influences the probability of a farmer to take adaptation measures to climate change in the study area. The expected sign of the variable is positive.

3.4.3. Calculation of food self-sufficiency

Food self-sufficiency was measured through total energy available for consumption to households from their own farm production and requirement based on adult equivalent of respective household's family size for a year. The ratio of available energy from own production to required energy by the family member is referred to as the food self-sufficiency ratio (FSSR). The basic standard energy requirement of 2500 kcal/person/day was considered for one adult equivalent the study. The energy content of each grain food crops was considered and the moisture contents adjusted to 15% to get the dry matter. The major food crops considered were (sorghum, teff, mungbean, wheat, maize and Haricot bean) and their total available energy was calculated by multiplying energy content of each crops with the total dry matter (CBS, 2003a). In this study, cash crops, fruits and vegetables were not considered with the assumption that they are not consumed (cash crops) and have insignificant energy content, respectively. Therefore, FSSR is calculated by dividing the total energy produced on farm with total energy requirements by the household family. FSSR higher than one means that the family produces surplus energy from their own farm and they are food self-sufficient and if it is below one, food self-insufficient.

Calculation of food self-sufficiency ratio was based on the following equation

$$FSSR = \frac{\sum_{i=1}^{l} Qpi * Ei}{Er * h} \qquad (1)$$

Where $FSSR_i$ is the food self-sufficiency ratio for household i, Qpi is the quantity of on-farm produced food product i (kg or l), l is number of on-farm produced food products, Ei is the energy content of food product i (Kcal kg^{-1} or Kcal l^{-1}), Er is the energy requirement of one adult equivalent (Kcal), and h is total number of adult equivalents in the household Rufino *et al*., 2013 cited by Beyene *et al*., 2018. A one-way analysis of variance (ANOVA) was used to test the difference between the means of adopters and non-adopters of households. Analyses were performed using the Statistical Package for Social Sciences (SPSS) version 25.

4. RESULTS AND DISCUSSION

4.1. Demographic and Socio-demographic characteristics of respondents

The result indicated that more than 90% of adopters were male-headed households while it was 86.2% for non-adopters (Table 4). About one third of adopters did not attend school while about three-fourth of non-adopters had no chance of attending school. More than 70% of adopters had access to credit while only 35.4% of non-respondents had access to credit. Credit is considered vital in supplementing the meager resources that farmers have, to meet the costly financial requirements in their farming activities (Jones et al., 2013). Similar, more than90% of adopters received extension services while more than half the non-adopters received extension services. According to Kidane and Degnet (2001) high frequency of extension contact accelerates effective dissemination of information that enhances adoption of new agricultural technologies.

Table 4: Demographic and Socio-economic characteristics of respondents

	Variables	Adopters (n=139)		Non- adopters (n= 65)	
		Freq.	%	Freq.	%
Sex	Male	129	92.8	56	86.2
	Female	10	7.2	9	13.8
Education and experiences	Illiterate (%)	43	30.9	51	78.5
	Read and write	75	54.0	13	20.0
	Elementary	14	10.1	1	1.5
	High school	7	5.0	0	0

Institutional	Access to credit	99	71.2	23	35.4
linkage	Access to extension	128	92.1	38	58.5

Respondents who adopted agricultural practices implemented by AGP were younger (42.93) than the non-adopters (47.4) and the earlier had significantly larger family size than the latter (Table5). The family size of adopters' was not only larger than the national average family size (4.7) but also for the rural Ethiopia (4.9) and Amhara regional state (4.3) (CSA, 2007). Adopters had also significantly larger farm size (1.19 ha) than non-adopters, while the adopters' was also larger than the national average land holding size (1.17 ha) and Amhara regional state (1.21 ha) (CSA, 2014). The herd size of adopters' was (3.19 TLU) larger than non-adopters. However, the herd size of adopters' was lower than the national (3.7 TLU) and Amhara regional state (3.2TLU) average herd size (CSA, 2013).

Table 5: Age, resource endowment and access to market (Mean+SD) for adopter and non-adopter respondents in the study area

	Variables	Adopters (n= 139)	Non-adopters (n= 65)	P-value
		Mean	Mean	
	Age	42.93± 7.69	47.41± 10.51	.003
Resource endowment	Family size	5.63±1.63	4.52±1.14	.000
	Farm size (ha)	1.19 ± 0.31	0.78 ± 0.34	.000
	Livestock size (TLU)	3.19 ±1.56	1.80±1.32	.000
	Distance of the farm field from homestead (in hr)	0.24 ± 0.08	0.35 ± 0.14	.000
Market	Distance to the nearest market(in hr)	0.93 ± 0.38	1.32± 0.47	.000

TLU= tropical livestock unit; SD= standard

4.2. Types of agricultural practice implemented by AGP and adopted

The types of agricultural practices which have been advocated by AGP and adopted in the study area were categorized in to water smart, nutrient smart, carbon smart and knowledge smart based on their adaptation/mitigation potential (Table 6). Although implementation of one climate smart activities contribute indirectly to the other climate smart agriculture, the categorization of this study was mainly based on their major adaptation/mitigation potentials.

4.2.1. Water smart technologies

Respondents in the study area adopted only one water-smart agricultural practice (Table 6). Use of irrigation is vital for year-round reliable crop production, which contribute for enhancing the resilience of smallholder farmers. Irrigation is vital to reduces farmers' reliance on natural rainfall patterns, which reduces vulnerability to climatic variation (Woldegebrial *et al.*, 2015).The sources of irrigation water in the study area were hand-drawn or pumped well water, water diverted from natural rivers, or water delivered via diversion canals. One of the services provided by AGP is to train and encourage farmers to use irrigation for better agricultural productivity. Accordingly, out of the total adopters (61.9%, n=86) of them applied small-scale irrigation in their farmland. Water conservation practices such as rainwater harvesting, developing irrigation techniques and conserving soil moisture that can maximize water use efficiency are some of the activities adopted to withstand climate-imposed water scarcity (Hadgu *et al*., 2015; Jirata, 2016).

4.2.2. Nutrient-smart technologies

Respondents in the study area adopted six nutrient-smart agricultural practices (Table 6). Of the nutrient smart technologies more than 90% of adopters practice soil and water conservation activities followed by crop and livestock diversification (81.3%). The soil and water conservation practice mainly adopted by the farmers includes terraces (stone bund, soil bund), water harvesting structures mostly trenches and micro basins, gulley rehabilitation, and vegetation of around their farmlands to respond to climate change related problems such as flood and soil erosion. Specific technologies used in agricultural water conservation practices also include terracing across the slope of the cultivated land (Chimdesa, 2016). Integrated crop livestock-based diversification practices mostly adopted by the farmers in their farm land in order to increase production and respond to climate change. According to key informants and focus group discussion the integrated crop livestock-based diversification was one of the commonly used agricultural practices in the study area. The livestock sector and crop production sector are interdependent to each other in the study area i.e. crop residue are used as fodder for livestock and animal manure used for as organic fertilizer input to crops, which can enhance soil fertility and productivity.

Crop rotation was the third nutrient-smart technologies practiced by (67.6%) respondents (Table 6). Crop rotation diversifies soil nutrient utilization as different crops have different nutrient uptake. Crop rotation is the practice of growing a series of dissimilar or different types of crops in the same area in sequenced seasons. It is done with legume plants so that the soil of farms is not used for only one set of nutrients. Crop rotation is considered as effective means of maintaining the nitrogen status of the soils when leguminous plants were included in the rotation (Belay, 2000). The fourth important nutrient smart technologies were efficient use of fertilizer which was practiced by 65.5% of the respondents followed by intercropping. Intercropping reduces the climate driven crop failure as variety of crops have different climatic adaptability (Shava *et al.,* 2009). According to FGDs discussants intercropping is mainly implemented to ensure the availability of food from different crops and to obtain animal feed on continuous supply besides its role in improves soil fertility through crop diversification and provide soil cover to protect the impact of rain drop on soil and minimize erosion. The last but not least nutrient-smart technologies practiced were cover crops. Continuous cover crops can reduce on-farm erosion, nutrient leaching and grain losses due to pest attacks and build soil organic matter and improve the water balance, leading to higher yields (Lal 2008; Olson *et al*. 2010). Cover crops build and protect the health of the soil by replenishing the soil nutrients, preventing soil erosion and also hindering the growth of weeds which reduces the need for herbicides in future.

4.2.3. Carbon- smart technologies

Farmers practice three carbon-smart technologies which have the capacity to sequester carbon besides their other value such as produce or income diversification, soil fertility maintenance (Table 6). Any agriculture and land management practice that can increase the carbon in the soil and plant biomass by capturing atmospheric CO_2 can be regarded as carbon-smart (Lal, 2004). The three carbon-smart agricultural practices adopted were composting and manure management, tree planting and agroforestry (Table 6). Adopting organic fertilization (compost, animal, and green manure) is widely found to have positive effects on the yields.

Table 6: Types of agricultural practices implemented by adopters in the study area (n= 139**)**

Technology	Agricultural practices	Frequency	%
Water-smart (interventions that improve water use efficiency)	Use of irrigation	86	61.9
Nutrient-smart (interventions that improve nutrient use efficiency)	Soil and water conservation	126	90.6
	Crop livestock based diversification	113	81.3
	Use of crop rotation	94	67.6
	Efficient use of fertilizer	91	65.5
	Use of inter cropping	71	54.0
	Use of cover crops/ mulching	59	42.4
Carbon-smart (interventions that reduce GHG emission)	Use of composting and manure management	119	85.6
	Agroforestry	74	53.2
	Tree planting	65	46.6
Knowledge-smart (use of combination of science and local knowledge)	Use improved crop varieties	89	64.0

The result indicated in Table 6, shows that out of the total adopters (85.61%) of them practice compost and animal manure management practices in their farmlands followed by agroforestry (53.2%) and tree planting (46.6%). Composting has an advantage of cost-effective soil fertility improvement to increase the crop yield, reduce the greenhouse gas concentration through methane reduction, offset nitrous oxide (N_2O) released by application of inorganic fertilizer, and stabilize the soil moisture and organic matter content (FAO,2013). Tree planting are also well-known carbon sinks. They fix carbon through the process of photosynthesis and store excess carbon as biomass (Nowak and Crane, 2002; Singh, 2017). Agroforestry is land use management system that involves the integration of trees and shrubs into farmland either through planting or natural regeneration. Agroforestry have high potential for climate change mitigation, adaptation and crop productivity. Agroforestry enhance soil organic matter, agriculture productivity, carbon sequestration, water retention, agro biodiversity and farmers' income (Zomer *et al*., 2016; Singh, 2017).

4.2.4. Knowledge smart technologies

The use of improved crop varieties was one of knowledge smart technologies adopted by farmers in the study area. According to FGD discussion, the farmers used early maturing variety to respond to erratic rainfall and shortage of rainfall problems. The result indicates in Table 6 shows out of the total adopters 64.0% of them grow improved crop varieties.

4.3. Contributions' of implemented agricultural practices for enhanced productivity and income

4.3.1. Crop productivity

The result in Table 7 indicated the crop productivity advantage of implementing different climate smart technologies. Adopters obtained significantly larger yield for all crops except mungbean. The average teff and sorghum yield obtained by adopters were about 19 and 31 qt/ha compared to about 15and 25 qt/ha obtained by non-adopters (Table 7). The average yield of teff and sorghum produced by adopters' was also larger than the national average yield 17.48 and 27 qt/ha respectively (CSA, 2018). Similarly, adopters obtained about 37 and 45 qt/ha wheat and maize respectively compared to about 31 and 33 qt/ha for non-adopters. Compare to the national average yield 27 and 39 qt/ha wheat and maize respectively adopters' was obtained larger yield (CSA, 2018).

Table 7: The Mean productivity of major crops for adopter and non-adopters of the study area (Mean ± SD)

Total crop yield (qt/ha)	Adopters (N=139)	Non-adopters (N=65)	T-value	P- value
	Mean	Mean		
Teff	19.38 ±5.59	15.04 ±5.10	4.127	0.000
Sorghum	30.73 ±3.24	25.02 ±5.45	8.905	0.000
Mugbean	14.25 ±3.06	13.29 ±4.41	0.783	0.446
Wheat	36.78 ±3.77	30.67 ±2.31	3.815	0.018
Maize	44.80 ±8.71	32.67 ±6.41	3.517	0.004
Haricot bean	15.89 ±1.60	11.86 ±1.46	5.768	0.000
Onion	122.30 ±24.74	96.22 ±19.08	3.895	0.000

Source: computed from survey data, 2020

Therefore, this analysis indicated that as presented in the previous section shows adopted agricultural practices such as using of legumes in crop rotation, using of early maturing improved crop varieties, use of composting and manure management, inter cropping, use of small scale irrigation and efficient use of inorganic fertilizer have contributed climate smart agricultural practices option that increased crop productivity in the study area.

4.3.2. Income

Smallholders of the study area received the majority of their income from crops as it contributed 90% and 88% of the total income for adopters and non-adopters respectively (Table 8).

Table 8: Annual mean income of adopters and non-adopters in the study area (Mean+SD)

Major crop types	Average price (ETB/qt)	Adopters (n=139)	Non-adopters (n=65)	t-value	p-value
		Mean	Mean		
Teff	2534	15414 ±10873	8187 ±9563	4.591***	0.000
Sorghum	1063	18278 ±8467	14113 ±7676	3.369***	0.001
Maize	898	995 ±2938	511 ±1746	1.465	0.145
Mung bean	2358	6726 ±7814	2394 ±5379	4.042***	0.000
Wheat	1165	1886 ±5163	412 ±1892	2.229**	0.003
Haricot bean	1195	658 ±1785	441 ±1378	0.948	0.344
Onion	787.5	2459 ±4587	2241 ±3950	0.348	0.729
Total crop income		46410 ±16480	28300 ±11904	7.939***	0.000
Livestock		2062 ±2202	958±1689	3.578	0.000
Off- farm		2875±4985	2902±5886	-0.031	0.975
Total		51347 ±18467	32160 ±13538	7.485***	0.000

Source: survey data (2020), ****, ***** significant at α = 0.01 and α = 0.05 respectively

Adopter smallholder farmers received significantly larger income from teff, sorghum, maize, mungbean and wheat than non-adopters. This is may be due to larger productivity obtained by adopters. Livestock also contributed significantly larger income for adopters than non-adopters which can explain by the presence of large herd size with adopter farmers. Surprisingly, there was no significant difference of off-farm income between adopters and non-adopters. Livestock plays a significant role as income sources in rural poor Ethiopia. Sale of live animals and their products are main livestock-related income sources in the study area. The livestock income category includes income from the sales of livestock and livestock products. The average livestock annual income of adopters has 2061.9 ETB and the non-adopters were 958.2 ETB, while there was a positive association and significance difference at 5% level (Table 8). This result indicates that adopters were gained greater income from livestock than non-adopters to enhance food self-sufficiency through selling the existing stock of livestock in the study area.

4.4. The role of implemented agricultural practices for food self-sufficiency of households

Similar to income, cereals crops were the major sources of energy for both adopters and non-adopters (Table 9). Adopters produce significantly larger energy (38.2 GB) than non-adopters (24.62). The food self-sufficiency quantified in terms of energy availability indicated that both adopters and non-adopters were self-sufficient as they achieved more than 1% (Table 9). However, adopter's food self-sufficiency was higher by 118% then the required while for non-adopters; it was only 75% higher than the required. The achievement of food self-sufficiency above 1% is considered as an asset as farmers generate income from the excess produce. The findings in lined with Rufino *et al*., 2013 FSSR greater than one means that the households has a surplus of energy from on-farm production.

Table 9: Energy produced and food self-sufficiency of adopters and non-adopter farmers in the study area

Characteristics	Adopters (N=139)	Non-adopters (N=65)	t-test
	Mean	Mean	
Average family size in AE	4.89 ±1.28	4.14 ±10.33	
Total available energy in GJ	38.20 ±13.09	24.62 ±8.83	
Energy requirement in GJ	18.76 ±4.92	15.88 ±5.11	
Food self-sufficiency ratio	2.18 ±0.97	1.75 ±0.89	0.003

AE= adult equivalent

4.5. Factors influences the adoption of agricultural practices implemented by AGP in the study area

Binary logistic regression model describes the relationship between a dichotomous response variable (adoption of agricultural practices implemented by AGP) and a set of explanatory variables that aimed to contribute for climate smart agriculture among smallholder farmers in the study area. Before running the regression model, the explanatory variables were checked for the existence of multicollinearity. The problem of multicollinearity among the explanatory variables was tested using variance inflection factor and contingency coefficient for continuous and dummy explanatory variables respectively. The contingency coefficient and VIF values of the variables in the model as shown in Appendix Table 4 and Appendix Table 5 are less than the critical values showing that there was no multicollinearity problem. The findings of the binary logistic regression model indicated that significance and impact of each explanatory variable on the response variable. A model was employed to identify the major factors that influence the adoption of implemented agricultural practice by AGP.

Oates (2015) stated to observe the tests of individual variables in this model, the maximum likelihood, estimates (coefficients), the Wald statistics, confidence intervals and odds ratios (Exp (B)) were presented. The odds ratio estimates tells us the change in “odds” of being in one of the categories of the dependent variable for every unit increase of any given variable in the model. A value of one for the odds ratio means that there is no change in odds as the variable increased. A value of less than one for the odds ratio means that for every unit increase of a given variable the odds of adoption of agricultural practices implemented by AGP decreases. A value of more than one means that for every unit increase of a given variable the odds of adoption of agricultural practices implemented by AGP increases. In addition to the odds ratios, a 95% confidence interval for each of the odds ratio estimates was calculated. The Cox and Snell R Square and the Nagelkerke R Square are referred to as “pseudo R-squared statistics” as reported by Hosmer and Lemeshow (2001). Each of the logistic regression models passed the goodness of fit tests recommended by Pallant (2007) and Hosmer and Lemeshow (2001).

Finally, a set of 13 explanatory variables (8 continuous and 5 discrete) were included in the logistic analysis. Out of 13 hypothesized explanatory variables 8 (education, cultivated land size, extension contact, credit access, livestock holding size, labor proportion, income and farm distance) were a significant impact on participating to agricultural practices implemented by AGP. On the other hand, five explanatory variables (Sex, age, family size, market distance and off-farm activity) were not significantly affected the dependent variables. However, age, market distance and off-farm activity were negatively related with agricultural practices implemented by AGP (Table 10).

Education level of household head (EDUHH): is one of a statistically significant explanatory variable at 1% level of significance as shown by a p-value of 0.004 in table10. The coefficient is positive implying that education has a positive influence in decision taking for adoption measure to agricultural practices implemented by AGP. An increase in the level of education by one year from the mean educational level increases the probability of taking adoption measure by 5.1times keeping other things at their respective mean. This result is in support of the findings of Deressa *et al.* (2009) who found a positive relationship between education and adaptation to climate change in Ethiopia. This implies that, farmers with higher levels of education are more likely to use improved technologies in order to adapt to climate change and improve production sustainably. This is particularly so because educated farmers are more knowledgeable due to their ability to access information pertaining to climate change and adaptation options.

Access to credit (CREDIT): The results showed that access to credit was significant at 5% and positively influence on adopt agricultural practices implemented by AGP (B = 1.700). It indicates that access to credit leads to increase the farmer's decision to adopt agricultural practices implemented by AGP by a factor of 5.475 for every one unit increase in access to credit facility (Table 10). Agricultural practices implemented by AGP adoption needs money to purchase improved inputs such as fertilizer, improved seeds, improved livestock variety and others like different seedlings. Therefore, access to credit is very important to finance the purchase of necessary inputs for adapting to climate change and increase productivity. That is why here we found positive effect on adaptation decision. The result of this study is similar to the findings of Deressa *et al.* (2009) as well as Di Falco *et al.* (2011) which were found under the study conducted in Nile Basin of Ethiopia.

Extension contact (EXTENCON): The result as shown in table 10extension contact was significantly influence on agricultural practices implemented by AGP adoption at 5% and positive relation with agricultural practice (B = 2.443). Frequent extension contact enable to aware farmers about agricultural practice. The result shows that a unit increase extension service increases the likelihood of household head participation by factor of 11.5. Different farmers have different indigenous knowledge and skills, working habits and experience. Therefore, sharing of experience among farmers is very important to build up the knowledge of the farmers and will help them to take the adaptation measures. The finding was in lined with Deressa *et al*. (2010) and Leta (2018).

Total Livestock Holdings (TTLU): Livestock had a significant at 5% probability level and positively affect the household adoption of agricultural practice implemented by AGP in the study area. The positive sign of coefficient indicates that when livestock owned increase by one unit, the probability of household to become adopter of agricultural practice implemented by AGP also increase by a factor of 1.795. This result was consistent with some studies (Lemmi *et al*., 2013; Tessema *et al*., 2013; Aschalew, 2014) who found a positive relationship between total livestock holding (in TLU) and farmer's choice of climate smart agricultural practices.

Cultivated land size (LANDSZ): This variable was significantly affected participation of agricultural practice implemented by AGP at 5% and it was positively correlated (B = 2.553). The result shows that on average a unit increase in cultivated land size leads to increase participation of households to agricultural practice by a factor of 12.847 (other factors being constant). This shows that the bigger the farm size, the more these practices will be adopted. Therefore, in the study area large landholders are more sensitive to participation of agricultural practice implemented by AGP than those farmers who have small farm size. This finding is also in line with (Tadele, 2016) were found that farmers with large farm sizes can implement different agricultural practices at relatively lower level of impact compared to farmers with small sized farm lands.

Distance of the farm field from homestead (FARMDISTA): This variable was significant at 5% significant level and negatively affects adoption of farmers. This implies that, the remaining things the same, as the distance or the farm to the home increases by one unit the probability of farmers adopting agricultural practices implemented by AGP on his/her farm is likely zero as compared to non- adopter farmers (Table 10). The farm found at far distant may not be frequently getting visited, difficult to transport compost and manure and overall management. This finding is consistent with previous studies (Shitaye, 2015). On her findings conducted at Dawero Zone, Maraka Woreda, SNNPRS, She found and reported that the mean distance of farm plot from the home stead had a significant effect to adopting on farm land management practices in the study area. Farmers managed better the nearer farm than distance farm to the close observation of changes on nearer farm as well as the additional time and labour required to reach distant plot.

Income of households (INCOME): Income of households has a positive effect on farmers' adoption of agricultural practice implemented by AGP at 5% significance level (B = 0.000). Income is central to the livelihood activities of farmers. There are financial implications of every choice of adaptation to the farmer. A unit increase in farm income increases participation of households to agricultural practice by a factor of 1.000 (other factors being constant). The implication of the result was that availability of farm income improves farmers' financial position, which in turn, enables them to purchase farm inputs such as, improved seeds and fertilizer. This study is consistent with the findings of Temesgen *et al*. (2014).

Table 10: Binary logistic regression model of factors affecting adaptation of agricultural practices implemented by AGP

Explanatory Variables	Coefficient(B)	S.E.	Wald	p- value	Odds ratios
HHSEX	1.210	1.012	1.428	.232^{NS}	3.352
EDUHH	1.629	.567	8.259	.004***	5.100
CREDIT	1.700	.665	6.538	.008***	5.475
EXTENCON	2.443	.922	7.025	.008***	11.502
OFFFARMHH	-.155	.739	.044	.834^{NS}	.857
AGEHH	-.048	.032	2.243	.134^{NS}	.954
HHFS	.325	.283	1.325	.250^{NS}	1.384
LABOR	1.363	.439	9.631	.002***	3.909
TLU	.585	.228	6.062	.010**	1.795
LANDSZ	2.553	1.156	4.882	.027**	12.847
MKTDISTA.	-.350	.768	.208	.649^{NS}	.705
FARMDISTA	-10.661	3.409	9.778	.002***	.000
INCOME	.000	.000	4.601	.032**	1.000

Number of observation = 204 -2Log likelihood = 75.388, Chi-square = 179.951, df = 13

Prob > chi^2 = 0.000, Nagelkerke R^2 = 0.821

***, ** significant at α = 0.01 and α = 0.05 respectively, NS = Not Significant

Source: survey data (2020)

Active labour force (LABOR): Active labor force (the percentage of household members' age between15to 64) had a positive influence on farmers' adoption of agricultural practice implemented by AGP at 1% significance level (B = 1.363). A unit increase in the number of active labour force increases participation of households to agricultural practice by a factor of 3.909. In this case having sufficient active labour force is, therefore, important in applying such adaptation. Hence, the farmers with more active labour force showed high preference for these adaptation strategies. The quantitative result was verified by transect walking how the practices demand much labour. The findings of this study align with Aschalew (2014) who found a positive relationship between active labour force availability and farmer's choice of climate smart agricultural practices.

5. CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

This study assessed contribution of agricultural growth program implemented agricultural practices for climate smart agriculture in Efratanagidm district of North Shewa, Ethiopia. Farmers who adopted climate smart agricultural practices implemented by AGP had larger farm size and livestock holding than the non-adopters. Larger number of adopters attended primary school compared to non-adopter farmers and the earlier were a bit younger than the latter. Furthermore, Adopters had better access to extension and credit then non adopters. Of the implanted climate smart technologies nutrient smart technologies were widely adopted followed by carbon smart. In total 11climate smart technologies were adopted. Adopters achieved significantly larger crop productivity and earn significantly higher income than the non-adopters. Although both adopters and non-adopters were food self-sufficient, the earlier achieved 118% more than the required energy compared to 75% achieved by the latter. Adoption of climate smart agricultural practices were significantly positively influenced by level of education, credit and extension services, labour availability, farm and herd size while significantly negatively influenced by distance of the farm field from homestead.

5.2. Recommendations

Based on the findings of the study, the following points are recommended for further consideration and improvement.

1. The major policy implication arising from the results of this study is that efforts has to be made to strengthen and encourage the adoption of climate smart agricultural practice and should be targeted towards low resource endowed farmers

2. In the study area, non-adopters of the AGP participant households' had low access to credit, extension advisory services and participation in many of the agricultural development activities. Hence, all responsible bodies should empower these groups of farmers through the provision of training and facilitating conditions for their full participation in any development agendas.
3. The results of the study give an important evidence on the contribution of agricultural growth program implemented agricultural practices for climate smart agriculture in Efratanagidm district, so governmental and non-governmental organizations in the study area should give due attention for adoption of improved agricultural technologies to increase agricultural productivity and income of households in the study area.
4. For further study, this paper recommends research to be undertaken on farmers' knowledge and their existing experience about agricultural practice prioritization and criteria used for prioritization.

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APPENDICES

Appendix 1: Household Survey Questionnaire

My Name is Dereje Mandefro. I am a student at Hawassa University doing my MSc. Degree in Climate Smart Agriculture and Landscape Assessment. I am conducting my master's thesis on Contribution of agricultural growth program implemented agricultural practices for climate smart agriculture and its implication to household income and climate change adaptation in Efratanagidm District of North Shewa Zone, Ethiopia in this area.

Dear respondents, the result of this study will help different stakeholders and policy makers to make appropriate measures on climate smart agriculture in the future. The information you will give will be strictly confidential. All the answers and information you provide are correct; no wrong answers can be given. If you have any questions, please do not hesitate to ask. Thus, you are kindly requested to provide genuine responses. Thank you for your time and collaboration!

Instructions

During the process put the answer of each respondent both on the space provided and encircle in the choose

Please ask each question clearly and patiently until the farmers understands (gets your point).

Please fill up the questionnaire according to the famer reply (do not put your own opinion).

Where choices are unavailable try to give the answer on the space provided.

Please do not try to use technical terms while discussing with women and do not forget to record the local unit.

1. **General information of household**

1.1. Region: Amhara, Zone: North Shewa, District: EfratanaGidm

1.1.1. Survey kebele ……………… village …………… Name of

1.2.Enumerator………………Date ………Signature……Questionnaire code……

1.3.Participant status: 1 = AGP Adopter, 0 = Non- adopter

1.4.Checked by ……… ………………. Date …………….signature ……….

2. Respondents demographic information

2.1.Name of household head……………………………………………

2.2.Sex of household head: 1 = male, 2 = female

2.3.Age of household head: ……… (Year)

2.4.Educational level of household head: 1. Illiterate. 2. Read and Write (1-4). 3. Elementary school (5-8). 4. High school (9-12) and above

2.5.Marital status: 1. Married. 2. Single. 3. Widowed. 4. Divorced

2.6. How do you categorize your family labor for irrigated activities?1. Small. 2. Enough. 3. Large. 4. Exclusive

2.7.Which income source is the major contributing activity? 1. irrigated agriculture. 3. Rain fed agriculture. 3. Both rain fed and irrigated agriculture. 4. Others specify

2.8.Household members

No.	Age	Numbers		
		Male	Female	Total
1	0-15 years			
2	15-65 years			
3	Above 65 years			

3. **Socio economic factor related questions of HHs**

3.1. Do you have livestock? 0. No 1.Yes

3.2.If the answer to Q 3.1 is yes how many of the following types of livestock do you have and died in the past 12 months (2011 E.C)? Please fill the following columns.

S/No.	Livestock type	Quantity (head)	Died	Reason
1	Oxen			
2	Cow			
3	Camel			
4	Donkey			
5	Horse			
6	Poultry			
7	Goat			
8	Sheep			
9	Beehives			
10	Others(specify)			

3.3.Do you have own land? 0 = No; 1 = Yes

3.4.If Yes, Q 3. 3 how many hector (timad) of land do you have? _________

3.5.How do get the land: 1. Allocated by government 2. Rented from individual farmers 3. Share cropped in 4. Inherited

3.6.Do you have tenure security certificate for your land? **1= Yes 0= No**

3.7.What are the physical characteristics of your farm, in terms of its exposure to erosion?1= Susceptible to erosion 2= moderately susceptible to erosion 3= Not susceptible all

3.8.How was the fertility of the soil of your farm in general? 1= Very fertile .... 2= Moderate................ 3= Poor/ infertile

3.9.What is your source of income? 1. Only Agriculture 2. Agriculture and off-farm 3.Agriculture and Non- farm 4. Agriculture, off farm and nonfarm

3.10. Which farming activities are you following currently? 1. Only crop production2. Livestock raring 3. Mixed farming (Crop production and livestock raring 4. Others

3.11. How much income can you generate from your agricultural farming activities during last production year (i.e. 2010 /2011)? Please specify in Birr:

3.11.1. **From crop production**

Types of crop grown	Area cultivate in timad.	Quantity produce/ Kilogram	Quantity consumed (kg)	Quantity sold (kg)	Average price for each crop (Birr/Qt)	Estimated income gained per year (Birr)
Teff						
Sorghum						
Maize						
Wheat						
Chickpea						
Mungbean						
Haricot bean						
Subtotal income						

3.11.2. **From livestock production**

Types of livestock	No. of livestock sold last year	Average price for each (birr)	Income gained (birr)
Oxen			
Cow			
Camel			

Donkey			
Horse			
Poultry			
Goat			
Sheep			
Heifer			
Calf			
Bull			
Subtotal income			

3.11.3**. Incomes from livestock products and by products**

Type of products and by products	Unit	Quantity	Amount collected	Amount consumed/year	Sold per year and gained income(birr)
Milk					
Butter					
Egg					
Honey					
Subtotal					

3.11.4. Annual household's income from irrigated non-vegetable crop products during the 2010/2011 E.C production year.

Crop type	Cultivated land in timad	Total annual harvested(Qt)	Consumed (Qt)	Sold(Qt)	Unit price(birr)	Total gained(birr)
Teff						
Mung bean						
Mango						
Avocado						
Banana						
Coffee						
Orange						
Papaya						
Subtotal						

3.11.5. Annual household's income for irrigated income vegetable crops production during the 2010/2011 E.C production year.

Crop type	Cultivated land in timad	Total annual harvested(Qt)	Consumed (Qt)	Sold(Qt)	Unit price(birr)	Total gained(birr)
Onion						
Tomato						
Cabbage						
Pepper						
Potato						
Subtotal						

3.12. **Other income source**

3.12.1. Do you have accessed to other income source? 1 = Yes, 2 = No

3.12.2. If **yes,** what is the source of your income?

Sources of income	Quantity	Amount in birr		Remark
		Month	Year	
Farm implements sale				
House rent				
Grass and hay sale				
Fuel and charcoal sale				
Fuel wood sale support from relatives				
Food for work				
Food aid				
Cash for work				
Petty trade				
Others				

4. Institutional factors related questions

4.1.Did you use any type of credit services? 0 = No; 1 = Yes

4.2.If yes Q 4.1 for what purposes do you obtained credit?

1. Purchase of improved seed 2. Purchase of fertilizer
3. Purchase of farm equipment 4. To fill up family requirement
5. Livestock purchase 6.Petty trade 7. Others (specify)

4.3.If No, Q 4 .1 why you are not take credit?

1. Fear of inability to repay 2. High interest rate 3 .Lack of collateral

4. I do not want to take 5.Unavailable on time7. Others (Specify)

4.4.What is the source of the credit? ____

4.5. Do you have contact to agricultural extension services? 0 No 1 Yes

4.6.If yes Q 4. 5. How many times extension workers visit in a year ____

4.7.What types of advices did you get from extension workers? Please circle your answer.

1. Improved crop production systems 2.Improved livestock production
3. Integrated crop livestock management 4.Intercropping 5. Planting and harvesting time
6. Soil and water conservation management 7. Irrigation use 8. Crop rotation
9. Others (please specify) ____

4.8.How long does it take to reach your farm from your home? Distance (in KM ____________ In terms of time it takes (in min) _____________

4.9.How far the market where you buy your agricultural inputs and sale products (e.g. hoes, seeds, fertilizers, etc)? Distance in KM........ In terms of time it takes (in minutes)................?

5. Question on types of AGP implemented agricultural practices

5.1.Do you know about agricultural growth program /AGP/ project? **0= No 1= Yes**

5.2.If the answer to Q 6.1. Is yes in your understanding please explain-------------

5.3.Did you participate in the AGP project activities like trainings, experience sharing and demonstration activities, small scale irrigation, natural resource conservation and rehabilitation, improve crop and livestock production? _______ 0 = No; 1 = Yes;

5.4.If YES, in which of the following project interventions (implemented by AGP) did you participate? **Tick all that apply**

S/N	Type of agricultural practices by AGP	Response	
		1 = Yes	0 = No
1	Soil and water conservation		
2	Legumes in crop rotation		
3	Irrigation		
4	Integrated crop livestock based diversification		
5	Intercropping		
6	Planting tree		
7	Organic fertilizer/Using of compost		
8	Use of cover crops /Mulching		

9	Agroforestry		
10	Improved crop varieties		
11	Efficient use of fertilizer		

5.5.Has your households benefited from AGP Project? ________ 0 = No; 1= Yes

5.6.If Yes to question 6.6. What benefits do you get? Please mention the major benefits.

____

5.7.Can you mention the types of climate smart crop production practices supported by AGP?_____________________,______________________,_____________________

5.8.In which crop technologies were introduced by AGP? 1. ________________2.________________3.__________________4. _____________

5.9.Indicate the type of technology used during the AGP project; continue to use and source of information. ________________, ________________, ________________________, ____________________, _____________________,

5.10. Does AGP project have positive contribution to income/food security for your family: 0 = No; 1 = Yes;

5.11. If No; what was the reason behind it? ----------------------------------

5.12. What are the main constraints/challenges to encounter during the implementation of AGP for climate smart agricultural practices? --- ---

Appendix2: Key Informant Interview questions

Name..Age …………… Sex………………

Educational status ………………………… Position/profession-----------------------

1. Do you believe that there is climate change in the locality? What are the indicators? ------ -- --
2. What are the main effects of climate change on the crop production and livelihood of farmers in your area? _________________________, _______________________, ________________________, ________________________, ________________________
3. Does agricultural growth program (AGP) contribute for climate smart agriculture in your area? 0 = No; 1 = Yes;

4. If yes Q. 4 what types of agricultural practices used? Please list the most common agricultural practice implemented by AGP in this district. ______________________, ________________________,_______________________,___________________________
5. Does the farmer use any climate smart agricultural practices to response climate related problems? 0 = No; 1 = Yes;
6. If yes Q. 6 what types of climate smart agricultural practices used please mention the most common climate smart agricultural practices practiced in this district. _______________________,________________________,____________________________

   What are the factors that constraint in climate smart agriculture practices?

   _______________________,________________________,__________________________
7. What types of information farmers need about climate change and adaptation of climate smart agricultural practices? ______________________, ________________________, ____,_______________________,

   What do you suggest to be done to reduce the impacts of climate change in yours district.

   _______________________,________________________,____________________________ ,

Appendix 3: Check list for Focus Group Discussions

1. What are the major agricultural activities undertaken in the area?
2. What are the major sources of income to support livelihood in the area?
3. What benefit do you obtain from AGP?
4. What climatic change related shocks in the area?
5. Does it help you enhance climate change adaptation during food shortage?
6. What are the major agricultural practices used in the local area.
7. What are the determinants of farmers' choice to adapt climate smart agricultural practices?

Appendix4: Contingency coefficient test of categorical explanatory variables

Explanatory variables	Sex of house holds	Credit access	Non-farm employment	Education status	Extension contact
Sex of households heads	1				
Credit access	-.016	1			
Non-farm employment	-.116	.123	1		
Education status	.016	-.169	-.046	1	
Extension contact	.285	-.029	-.148	-.174	1

Source: own survey 2020

Ap**pendix 5: Variance Inflation Factor (VIF) test of continues explanatory variables**

Independent Variables	Tolerance	VIF
Age of household head	0.932	1.073
Total Household Members	0.744	1.345
Family labor for farming activities	0.801	1.248
Total livestock size of households (TLU)	0.871	1.148
Total household land size in hector	0.659	1.517
Market distance of households (Min)	0.754	1.326
Farm distance of households (Min)	0.796	1.257
Total annual income of households (ETB)	0.708	1.413

Source: own survey 2020

Appendix 6: Livestock conversion factor

Livestock	Conversion factor	Livestock	Conversion factor
Oxen	1.1	Goat	0.1
Cow	1.0	Donkey	0.5
Heifer	0.5	Mule	0.7
Calf	0.2	Hen	0.01
Sheep	0.1		

Source: (Land O'Lakes International Development, 2007).

Appendix 7: Conversion factor used to calculate adult equivalence scales

Age groups (in years	Male	Female
0-2	0.4	0.4
3-4	0.48	0.48
5-6	0.56	0.56
7-8	0.64	0.64
9-10	0.76	0.76
11-12	0.8	0.88
13-14	1	1
15-18	1.2	1
19-59	1	0.88
60+	0.88	0.72

Source: World Bank (2010)

Appendix 8: Crop yield and nutrient composition of Major crops grown

Food item	Unit	Calorie	Food item	Unit	Calorie
Teff	Kg	3589	Sweet potato	Kg	1370
Wheat	Kg	3574	Irish potato	Kg	840
Barely	Kg	3723	Coffee	Kg	1103
Maize	Kg	3560	Salt	Kg	1700
Sorghum	Kg	3805	Check pea	Kg	3630
Peas	Kg	3553			
Vetch	Kg	3470			
Linseed	Kg	5109			
Haricot bean	Kg	3514			

Source: EHNRI, 2000

Appendix 9: Crop production value of annual price in the study area (ETB/Qt)

Crop Type	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	average Price
Teff	2650	2760	2520	2465	2430	2420	2440	2480	2520	2530	2540	2650	2534
Sorghum	1080	1150	1160	1200	1100	950	1080	1060	950	980	960	1080	1063
Maize	950	920	890	925	900	900	850	840	820	900	925	950	898
Mungbean	2200	2500	2600	2500	2400	2300	2300	2240	2360	2250	2300	2350	2358
Wheat	1500	1250	1000	1050	1050	900	940	1050	1250	1250	1350	1400	1165
Haricot bean	1100	1000	1200	950	1050	1250	1300	1250	1200	1300	1350	1400	1195
Onion	850	950	1000	800	750	650	700	650	700	850	750	800	787.5
Tomato	500	550	500	650	550	650	500	560	650	500	450	600	555
Cabbage	450	400	350	400	500	350	400	400	500	350	400	400	408

Source: Efratana gidm woreda trade and market development office annual report (2019)